(19) Europäisches Patentamt
Eur pean Patent Office
Offic européen des brevets

(11) Publication number: 0 244 005 A1

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 87200665.5

(22) Date of filing: 08.04.87

(51) Int. Cl.³: G 11 B 7/007
G 11 B 23/00, G 11 B 7/26

(30) Priority: 21.04.86 NL 8601006

(43) Date of publication of application: 04.11.87 Bulletin 87/45

(84) Designated Contracting States: DE FR GB NL SE

(71) Applicant: N.V. Philips' Gloeilampenfabrieken
Groenewoudseweg 1
NL-5621 BA Eindhoven(NL)

(72) Inventor: Hamer, René Hendrik
c/o INT. OCTROOIBUREAU B.V. Prof. Holstlaan 6
NL-5656 AA Eindhoven(NL)

(72) Inventor: Pasman, Johannes Hermanus Theodorus
c/o INT. OCTROOIBUREAU B.V. Prof. Holstlaan 6
NL-5656 AA Eindhoven(NL)

(74) Representative: Beckers, Hubertus Franciscus Maria et al,
INTERNATIONAAL OCTROOIBUREAU B.V. Prof. Holstlaan 6
NL-5656 AA Eindhoven(NL)

(54) **Method of scanning a radiation-sensitive recording surface of a rotating disc-shaped carrier by means of a modulated radiation beam and optical write apparatus for carrying out the method.**

(57) By means of an optical write apparatus 1 a rotating carrier 4 provided with a radiation-sensitive layer 5 is scanned with a radiation beam 7 which by means of a modulation device 13 is modulated in conformity with the information to be recorded on the layer. The beam is aimed at the radiation-sensitive layer 5 at a target point 20 by means of an optical system (10, 11, 12, 14, 15, 17, 18). During scanning the target point is radially moved in accordance with a predetermined motion. For this purpose the optical write apparatus 1 comprises a first actuating device 19 for the radial displacement of the optical head 16 and a second actuating device 10 for deflecting the radiation beam 7. A control device 21 controls the actuating devices 10 and 19 in such a way that the target point 20 performs a predetermined composite motion in radial direction, which motion is composed of a non-reversing motion component produced by the first actuating device and a reciprocating motion component produced by the second actuating device. This results in a very accurate low-vibration reciprocating radial motion of the target point, which enables information to be recorded along a multiple spiral by means of a single-spot write apparatus. Moreover, a very rapid and accurate recording of the information along concentric tracks is possible.

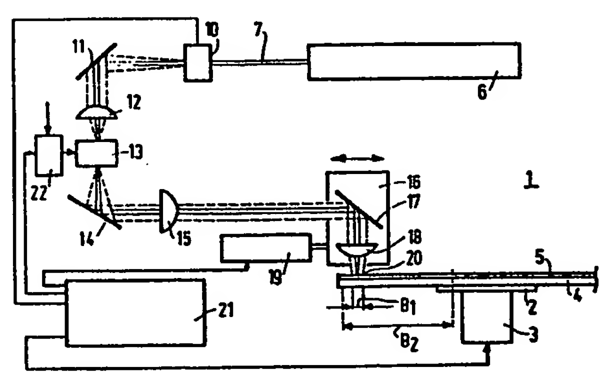

FIG.1

EP 0 244 005 A1

Croydon Printing Company Ltd.

"Method of scanning a radiation-sensitive recording surface of a rotating disc-shaped carrier by means of a modulated radiation beam and optical write apparatus for carrying out the method".

The invention relates to a method of scanning a radiation-sensitive recording surface of a rotating disc-shaped carrier along predetermined concentric or spiral paths by means of a modulated radiation beam which is aimed at a target point on the record carrier, the target point being moved over the recording surface in a radial direction in accordance with a predetermined motion by means of a first actuating device.

The invention also relates to an optical write apparatus for carrying out the method, comprising a drive means for rotating a disc-shaped carrier having a radiation-sensitive recording surface, an optical system for aiming a radiation beam at a target point on the recording surface, and a first actuating device for moving the target point in a radial direction within a first displacement range under control of a control device.

Such a method and apparatus are known from Netherlands Patent Application 72 12 045 (PHN 6519). Said Application describes a method and apparatus for the manufacture of master discs for making copies of optically readable record carriers. In accordance with said method a disc-shaped carrier provided with a recording surface formed by a photoresist layer is rotated by a drive means. The carrier rotated by the drive means is scanned by a laser beam which is aimed at the photoresist layer by the optical system. The drive means is arranged on a slide which is capable of moving the drive means in such a way that the landing point of the laser beam on the photoresist is radially moved within a displacement range of the order of magnitude of the radius of the disc-shaped carrier. As a result of the rotation of the carrier and the radial displacement of the landing point of the laser beam the photoresist layer is scanned along a spiral path, the laser

beam being modulated in accordance with an on-off pattern determined by the information to be recorded. After the photoresist has been developed and the carrier has been subjected to a photo-etching process a master disc with an information structure arranged along a spiral track is obtained, which master disc can be used for making copies.

The known method and apparatus have the disadvantage that they are less suitable for the manufacture of masters discs for optically readable record carriers provided with a structure arranged along a multiple spiral, for example record carriers formed with a spiral groove between which a spiral information tranck is arranged. By means of the known method and apparatus a structure arranged along such a multiple spiral can be obtained only by first scanning the recording surface along one of the sub-spirals (for example the sub-spiral defined by the groove) and subsequently scanning the recording surface along the other sub-spiral defined by the information track, which requires a reversal of the radial direction of movement. As a result of hysteresis which is caused by backlash and the like and which result from the direction reversal in the actuating device an accurate positioning of the starting point of the second scan between the turns of the first sub-spiral already scanned is not possible. This presents a serious problem, in particular, in the manufacture of masters, where extremely stringent requirements are imposed on the positional accuracy ($\pm$ 20.10^{-9} m) of the second sub-spiral relative to the first sub-spiral.

Moreover, in the manufacture of master discs for record carriers having a structure arranged along concentric tracks the known method and apparatus have the drawback that during radial positioning undesired vibrations arise as a result of the inevitable changes in slide velocity which occur when changing over from one concentric path to another. These undesired vibrations make it necessary to observe some extra waiting time after a change to another concentric path to allow the vibrations to be damped out sufficiently before recording can be started.

It is the object of the invention to provide a method and apparatus of the type defined in the opening paragraphs, which mitigate the aforementioned drawbacks.

For the method this object is achieved in that a second actuating device is employed in order to obtain a composite motion of the target point, which motion is composed of a first and a second radial motion component produced by the first and the second actuating device respectively, the first and the second actuating device being controlled in such a way that the first motion component is a predetermined motion whose direction is not reversed and the second motion component is a predetermined reciprocating motion.

For the apparatus this object is achieved in that the optical write apparatus comprises a second actuating device for radially moving the target point over the recording surface within a second displacement range smaller than the first displacement range under control of the control device, which control device is adapted to control the first and the second radial motion component produced by the first and the second actuating device in conformity with a first and a second predetermined motion profile respectively, the exposure of the recording surface to the radiation beam being interrupted at least during the return of the reciprocating motion.

The invention is inter alia based on the recognition of the fact that scanning along concentric paths or multiple spirals is possible in the case of a motion of the target point which is composed of a non-reversing motion component and a reciprocating motion component over a limited displacement range.

Scanning along a multiple spiral (for example a two-fold spiral) is possible by so controlling the position of the target point that alternately parts of one sub-spiral and parts of the other sub-spiral are scanned in such a way that after scanning of a limited number of turns of one sub-spiral the target point return to the point where scanning of the other sub-spiral was discontinued.

Scanning along concentric paths is possible by compensating for the first motion component by the second motion component in such a way that the radial position of the target point remains constant. After scanning of one complete path the direction of the second motion component is reversed until the radial position required for the next path is reached, after which this next path can be scanned.

Further the invention is further based on the recognition of the fact that by means of the said characteristic steps an accurate movement is obtained because the non-reversing motion component ensures that hysteresis in the first actuating device, which is difficult to keep within the specified tolerances on account of the large displacement range, has no influence the accuracy. Moreover, a non-reversing motion produces less undesired vibrations. The reversal of the direction of the target point, which is inevitable when scanning along multiple spiral, is now obtained by means of an actuating device with a small displacement range. In the case of an actuating device having a small range the hystereses can be kept within the required tolerances in a comparatively simple manner. Moreover, the undesired vibrations caused by the reciprocating motion are smaller.

A method of scanning the recording surface along concentric paths is characterized in that the first motion component is a motion with a substantially contstant velocity and the second motion component compensates for the first motion component during the forward portions of the second motion components in such a way that the radial position of the target point remains constant, the duration of each forward portion at least corresponding to one revolution of the disc-shaped carrier.

Since the first actuating device need only generate a constant-velocity motion the first actuating device will produce hardly any undesired vibrations, so that undesired vibrations in the motion of the target point are almost restricted to undesired vibrations of comparatively low amplitude determined by the second actuating device

with a limited range.

A method of scanning the recording surface along an n-fold spiral comprising n sub-spirals (n being an integer) is characterized in that in a cycle corresponding to n consecutive reciprocating motions during the consecutive forward portions of said motions, the recording surface is each time scanned along in integral number q (including 1) of turns of a following sub-spiral, for which purpose the velocities of the first and the second motion component during the forward portions are selected in such a way that the velocity of the composite motion is substantially proportional to the angular velocity of the carrier and for which purpose the velocities of the motion components during the return positions are selected in such a way that the target point is transferred to the point where scanning along the following sub-spiral is interrupted. This ensures that during each successive forward motion q turns of one of the sub-spirals are scanned. The resulting in-accuracy is mainly dictated by the comparatively small inaccuracy of the second actuating device with the limited range.

In one embodiment the optical write apparatus is characterized in that the second actuating device is an acousto-optical actuating device for deflecting the radiation beam which is aimed at the recording surface.

The absence of mechanical components in the acousto-optical modulator results in a very accurate yet almost vibration-free reciprocating motion.

Embodiments of the invention will now be described in more detail, by way of example, with reference to Figures 1 to 8, of which

Fig. 1 shows an optical write apparatus in accordance with the invention,

Figs. 2, 3, 4 and 9 show a number of paths described by the target point to explain the inventive method,

Figs. 2a, 3a, 4a represent the motion components then produced by the first and the second actuating device and the target-point motion composed of these components as a function of the angular displacement of the carrier,

Fig. 5 shows an example of the control device of the optical write apparatus, and

Figs. 6, 7 and 8 show parts of the control device.

Fig. 1 shows an optical write apparatus 1 in accordance with the invention. The write apparatus 1 comprises a turntable 2 which is rotated by a drive means 3. A disc-shaped carrier 4 provided with a light-sensitive layer 5, for example a photo-resist layer, can be placed on the turntable 2.

A laser 6 emits a light beam 7 which is projected onto the light-sensitive layer 5. The light beam 7 is first passed through a deflection device 10. The deflection device 10 is of a type by means of which a light beam can be deflected very accurately within a small range. Suitably, the deflection device is an acousto-optical modulator. However, it is also possible to use other deflection devices, such as for example a mirror which is pivotable through a small angle. The limits of the deflection range are indicated in broken lines in Fig. 1. The light beam 7 deflected by the deflection device 10 is directed to an optical head 16 via a mirror 11, a lens 12, a modulation device 13 for modulating the light beam 7, a mirror 14 and a lens 15. The optical head comprises a mirror 17 and an objective 18 for focussing the light beam on the light-sensitive layer 5. The optical head is radially movable reltive to the rotating carrier 4 by means of a positioning device 19.

By means of the above optical system the light beam 7 is aimed at a target point 20 on the light-sensitive layer 5, the position of this target point 20 being determined by the magnitude of the deflection of the light beam 7 produced by the deflection device 10 and the radial position of the write head 16 relative to the carrier 4. In the shown position of the optical head 16 the target point 20 can be moved by means of the deflection device 10 within a range indicated by B1. For the deflection shown the target point can be moved over a range designated B2 by moving the optical head 16. Further, the optical write apparatus comprises a modulation generator 22 for generat-

ing a modulation signal for the modulation device 13. Moreover, the optical write apparatus 1 comprises a control device 21 which, for controlling the motion of the target point 20, is coupled to the deflection device 10, the positioning device 19 and the actuating device 19 and which control device is coupled to the modulation generator 22 in order to synchronize the modulation signal with the motion of the target point 20 over the light-sensitive layer 5.

By means of the optical write apparatus 1 the photoresist layer 5 can be scanned with the light beam 7 along a multiple spiral, so that information can be recorded along a multiple spiral.

Fig. 2 shows an example of the path which may be described by the target point 20. The centre of rotation about which the disc-shaped carrier 4 is rotated is indicated by the reference numeral 30. The path which may be followed by the target point 20 in a radial direction is designated 31. The angle between the path 31 and a radius 32 issuing from the centre of rotation 30 and situated on the record carrier 4 is designated φ. The sub-spirals A and B together constitute the two-fold spiral along which the information to be recorded should be arranged. During a first revolution of the carrier 4 ($0 < \varphi < 2\pi$) the target point is moved from a position 34 in a radial direction indicated by the arrow 33 with a velocity proportional to the circumferential velocity of the carrier 4, so that the target point 20 follows a spiral path on the carrier 4. In Fig. 2a the corresponding radial displacement Sr is plotted as a function of φ. After one revolution the target point has reached a position 35, after which the target point 20 is returned over a distance corresponding to half the track pitch Tp during the next revolution ($2\pi < \varphi < 4\pi$), so that at the end of the second revolution the target point 30 has reached a position 36. Subsequently, during the next revolution ($4\pi < \varphi < 6\pi$) the target point 20 is again moved in the direction indicated by the arrow 33 with a velocity proportional to the angular

velocity, so that the light-sensitive layer 5 of the carrier 4 is scanned along the first turn of the sub-spiral B.

When the target point 20 has reached the end 37 of the first turn of the sub-spiral B the target point is returned in a radial direction during one revolution ($6\pi < \varphi < 8\pi$) until position 35 is reached, to effect scanning along the second turn of the sub-spiral A. In this way the photoresist layer 5 can be scanned alternately along the turns of the sub-spiral A and the turns of the sub-spiral B, the light beam 7 being modulated in conformity with the information to be recorded during the time intervals TA and TB (in which the photoresist layer is scanned along the sub-spiral A and the sub-spiral B respectively). During the time interval in which the target point is moved from one sub-spiral to an other (indicated by a broken line in Fig. 2), the light beam 7 is interrupted by the modulation device 13, so that no recording is effected. It will be appreciated that for moving the target point from one sub-spiral to another sub-spiral any path is permissible whose end point corresponds to the desired starting point of the next scan. The radial displacement Sr is partly determined by a displacement component Sk produced by the positioning device 19 and a displacement component Sa produced by the deflection device 10. In Fig. 2a Sk and Sa are also plotted as a function of φ. As is apparent from Fig. 2a, the target point 20 performs a radial motion which is composed of a motion component whose direction is not reversed and which is determined by the variation of the displacement component Sk and of a reciprocating motion component which is determined by the variation of the displacement component Sa.

Since the direction of the motion component produced by the positioning device 19 is not reversed hysteresis in the positioning device 19 does not affect the positioning accuracy of the target point 20. Tne reversal of the direction of the radial motion of the target point 20, which is inevitable when scanning the two-fold spiral, is obtained by means of the reciprocating motion component produced by

the scanning device 10. Since the range B1 of the deflection device 10 is amall relative to the displacement range B2 of the optical head, the inaccuracy caused by hysteresis is much easier to be kept within the required tolerances for the deflection device 10, thus ensuring an accurate positioning of the target point 20. When an acousto-optical deflection device is employed a very accurate positioning is possible owing to the absence of mechanical components.

Moreover, the use of an acousto-optical deflection device enables very rapid radial displacements of the target point 20 to be obtained, so that after scanning one turn of a sub-spiral it is possible to return almost immediately to the point where scanning of the other spiral was interrupted. The parth described by the target point and the associated variation of Sr, Sa and Sk are illustrated in Fig. 3 and Fig. 3a respectively.

The path followed by the target point 20 when changing over from scanning one spiral to scanning of the other spiral is represented in broken lines in Fig. 3. Since the radial displacement of the target point cannot be performed in an infinitely short time the turns of the sub-spirals will not be entirely contiguous. However, these errors are so small that this presents no problem for most uses.

Figs. 9a and 9b show another variant of the inventive method where the turns of each of the two sub-spirals are not situated exactly at half the distance between two consecutive turns of the other sub-spiral, but for example at 1/4 of this distance.

In the foregoing scanning along a two-fold spiral has been illustrated. However, it will be evident to those skilled in the art that in the similar way scanning along a multiple spiral comprising more than two sub-spirals can be effected.

In the scanning method described above the radial position of the target point 20 is controlled in such a way that alternately portions of one sub-spiral and portions of the other sub-spiral are scanned, the target point, after

scanning of a portion of one sub-spiral, returning to the point where scanning of the other sub-spiral was interrupted. In the present example the lengths of the alternately scanned portions of the sub-spirals correspond to the

length of one turn. It will be appreciated that, in principle, any arbitrary length is permissible, provided that when the scanning of one sub-spiral is interrupted scanning proceeds at the point where the scanning of the other sub-spiral was interrupted.

Further, it will be evident that S and Sk can be varied in numerous ways. In this respect it is only important that the displacement of the target point proceeds in a desired manner and that the direction of the motion component determined by Sk is not reversed. An accurate radial motion of the target point 20 is then always guaranteed.

Fig. 4 shows the paths followed by the target point when the light-sensitive layer 5 is scanned along concentric tracks. Fig. 4a illustrates the associated variation of Sr, Sa and Sk as a function of φ .

When concentric paths C, D, E, F, G and H are scanned the displacement component Sk is fully compensated for by the displacement component Sa, so that Sr remains constant when concentric tracks are scanned. After every complete revolution of the carrier 4 the target point 20 is moved over a distance corresponding to the track pitch Tp by means of the deflection device 10. For the given variation of Sk the optical head is moved with a substantially constant velocity, resulting in a substantially vibration-free movement of the optical head. The velocity changes in the velocity of the radial motion of the target point are obtained by means of the acousto-optical deflection device 10, which is almost vibration-free, so that a very rapid and substantially vibration-free motion of the target point from one concentric track to the other is obtained, enabling the recording process to be started rapidly owing to tne absence of a waiting time after a displacement.

In the method of scanning the photoresist layer along concentric paths as described herein, the variation of Sk and the variation of Sa are such that the resulting velocities are proportional to the circumferential velocity

of the carrier 4. It will be evident that Sa and Sk can be varied in numerous ways. In this respect it is merely important that the displacement of the target point proceeds in the desired manner and that the motion determined by Sk is a non-reversing and uniform motion. In this way an accurate and substantially vibration-free motion of the target point is then always guaranteed.

Fig. 5 shows a block diagram of the control device 21. The control device 21 comprises a programmable computing unit comprising a central processing unit 40 (CPU), a read-only memory 41 (ROM) and a random-access memory 42 (RAM). The memories 41 and 42 are connected to the central processing unit 40 in the customary manner _via_ a bus 43. A control unit 44 for controlling the modulation generator 22, a control unit 45 for controlling the deflection device 10, a control unit 46 for controlling the positioning device 19, and a control unit 47 for controlling the drive means 3 are also coupled to the central processing unit 40 _via_ the bus 43.

Fig. 6 shows the control unit 47 in detail. The control unit 47 comprises an oscillator 50 for generating clock pulses of constant frequency, which are applied to a frequency divider 51 of a programmable type, whose divisor is adjustable by the central processing unit 40 _via_ the bus 43. The output of the divider 51 is applied to an input of a first-detection circuit 52. The output signal of a pulse generator 53 is applied to the other input of the phase-detection circuit 52, which pulse generator is mounted on the shaft of a motor 54 for driving the turntable 2 and is constructed in such a way that it generates a pulse signal Vp of a frequency which is proportional to the speed of the motor 54. The output signal of the phase-detection circuit 52, which is representative of the phase difference between the signal on its inputs, is applied to a control circuit 55 which depending on the phase difference generates a control signal which is applied to a power amplifier 56 for energizing the motor 54.

The phase-detection circuit 52, the control circuit 55, the amplifier 56, the motor 54, and the pulse generator 53 together constitute a phase-locked loop of a customary type for controlling the circumferential speed of the turntable 2 with a velocity which is proportional to the frequency of the output signal of the programmable frequency divider 51. The output signal Vp of the pulse generator 53 is applied to an input of the central processing unit 40.

Fig. 7 shows an example of the control unit 46 for controlling the positioning device 19. The control unit 46 forms part of a control system for controlling the position of the optical head 16 in conformity with a desired value which in the form of a digital code can be loaded by means of the central processing unit 41 into a register 60 connected to the bus 43. The control system comprises a motor 61 for moving the optical head 61 _via_ a reduction mechanism 62. A pulse generator 63 is coupled to the shaft to the motor 61. The pulse generator 63 is of a type generating two pulse-shaped signals V_1 and V_2 which are 90^o or 270^o phase-shifted relative to each other depending on the direction of rotation of the motor and which have frequency which is proportional to the speed of the motor 61. These signals V_1 and V_2 are applied to a circuit 64 which derives signals V_o and V_n from the signals V_1 and V_2 in such a way that pulses of V_o are generated if the motor rotates in one direction and pulses of V_n are generated if the motor rotates in the other direction.

The signals V_o and V_n are applied to respectively the count-up input and the count-down input of an up/down counter 65. By means of a difference circuit 66 the count of the counter 65, which is a measure of the position of the optical head 16, is compared with the desired position stored in encoded form in the register 60. The output signal of the difference circuit is applied to a digital-to-analog converter 67. The output signal of the digital-to-analog converter 67 is applied to an input of a control circuit 68. The control circuit 68 derives such an

energizing signal for the motor 71 from the output signal of the analog-to-digital converter 67 that the position of the optical head is in conformity with the desired values stored in tne register 60.

Fig. 8 shows an example of the control unit 45 for controlling the deflection device 10. The control circuit 45 comprises a register 80 into which a digital code can be loaded by the central processing means 40 via the bus 43. A digital-to-analog converter 81 converts the digital code into an analog signal which serves as a control signal for a voltage-controlled oscillator 82 of the customary type. The output signal of the oscillator 82 is applied to the control input of the acousto-optical deflection device 10 of a conventional type, a light beam 7 passed through the deflection device being deflected through an angle θ determined by the frequency of the signal on the control input.

By means of the control device described herein the angular velocity the carrier, the radial displacement Sa of the target point 20 produced by the deflection device 10, and the radial displacement Sk of the target point produced by the positioning device 19 are controlled in conformity with a predetermined pattern during scanning of the photoresist layer 5. For this purpose the control device 21 is controlled by a program stored in the read-only memory 41. When this program is performed the central processing unit 40 determines the angular spacing φ by counting the number of pulses of the signal V_p which it receives. Upon any variation of the number of pulses counted the central processing unit 40 adapts the contents of the registers 60 and 81 in order to bring the displacement Sa produced by the deflection device 10 and the displacement Sk produced by the positioning device 19 in conformity with the desired values corresponding to the specific angular spacing φ , as is illustrated for example in Figs. 2a, 3a and 4a. These desired values can be stored in one of the memories 41 or 42, for example in the form of a look-up table. However, if there is a simple relationship (as in

Figs. 2a, 3a and 4a) between the displacements Sa and Sk and the angular spacing φ the desired values can be computed simply by the central processing unit 40. The central processing unit 40 also controls the synchronisation of the modulation signal with the motion of the target point over the light-sensitive layer 51. As this synchronisation falls beyond the scope of the present invention, it will not be described in more detail .

The control device 21 described herein is constructed by means of a programmable computing unit. However, it will be evident that the control device can also be constructed by means of a "hard-wired" circuit.

The embodiment described herein employs an acousto-optical deflection device. It will be obvious to those skilled in the art that it is equally possible to utilize an electro-optical deflection device.

CLAIMS

1. A method of scanning a radiation-sensitive recording surface of a rotating disc-shaped carrier along predetermined concentric or spiral paths by means of a modulated radiation beam which is aimed at a target point on the record carrier, the target point being moved over the recording surface in a radial direction in accordance with a predetermined motion by means of a first actuating device, characterized in that a second actuating device is employed in order to obtain a composite motion of the target point, which motion is composed of a first and a second radial motion component produced by the first and the second actuating device respectively, the first and the second actuating device being controlled in such a way that the first motion component is a predetermined motion whose direction is not reversed and the second motion component is a predetermined reciprocating motion, the exposure of the recording surface to the radiation beam being interrupted at least during return of the reciprocating motion.

2. A method as claimed in Claim 1, of scanning the recording surface along concentric paths, characterized in that the first motion component is a motion with a substantially constant velocity and the second motion component compensates for the first motion component during the forward portions of the second motion components in such a way that the radial position of the target point remains constant, the duration of each forward portion at least corresponding to one revolution of the disc-shaped carrier.

3. A method as claimed in Claim 1, for scanning the recording surface along an n-fold spiral comprising n subspirals, characterized in that in a cycle corresponding to n consecutive reciprocating motions during the consecutive forward portions of said motions the recording surface is each time scanned along an integral number <u>g</u> (including 1)

of turns of a following sub-spiral, for which purpose the velocities of the first and the second motion component during the forward portions are selected in such a way that the velocity of the composite motion is substantially proportional to the angular velocity of the carrier and for which purpose the velocities of the motion components during the return portions are selected in such a way that the target point is transferred to the point where scanning along the following sub-spiral is interrupted.

4. A method as claimed in Claim 3, characterized in that the duration of one period of the second reciprocating motion component substantially corresponds to p revolutions, p being an integer larger than or equal to q, the velocities of the first and the second motion components during the forward portions of the second motion component being elected in such a way that the velocity of the composite motion is substantially proportional to the angular velocity of the carrier during an uninterrupted time interval which at least corresponds to q revolutions, and the target point being moved in a radial direction over a distance substantially corresponding to 1/n times the pitch of the n-fold spiral during one full period of the reciprocating motion component.

5. A method as claimed in Claim 4, characterized in that the first motion component is substantially zero during the forward portion of the second motion component.

6. A method as claimed in Claim 4, characterized in that the velocity of the first motion component is substantially proportional to the angular velocity of the carrier.

7. A method as claimed in Claim 4 or 5, characterized in that p is equal to q.

8. A method as claimed in Claim 4 or 5, characterized in that n is two.

9. An optical write apparatus for carrying out the method as claimed in Claims 1 to 8, comprising a drive means for rotating a disc-shaped carrier having a radiation-sensitive recording surface, an optical system for directing a radiation beam at a target point on the recording surface,

and a first actuating device for moving the target point in a radial direction within a first displacement range under control of a control device, characterized in that the optical write apparatus comprises a second actuating device for radially moving the target point over the recording surface within a second displacement range smaller than the first displacement range under control of the control device, which control device is adapted to control the first and the second radial motion component produced by the first and the second actuating device in conformity with a first and a second predetermined motion profile respectively.

10. An optical write apparatus as claimed in Claim 9, characterized in that the second actuating device is an acousto-optical deflection device for deflecting the radiation beam which is aimed at the recording surface.

11. An optical write apparatus as claimed in Claim 9, characterized in that the second actuating device is an electro-optical deflection device.

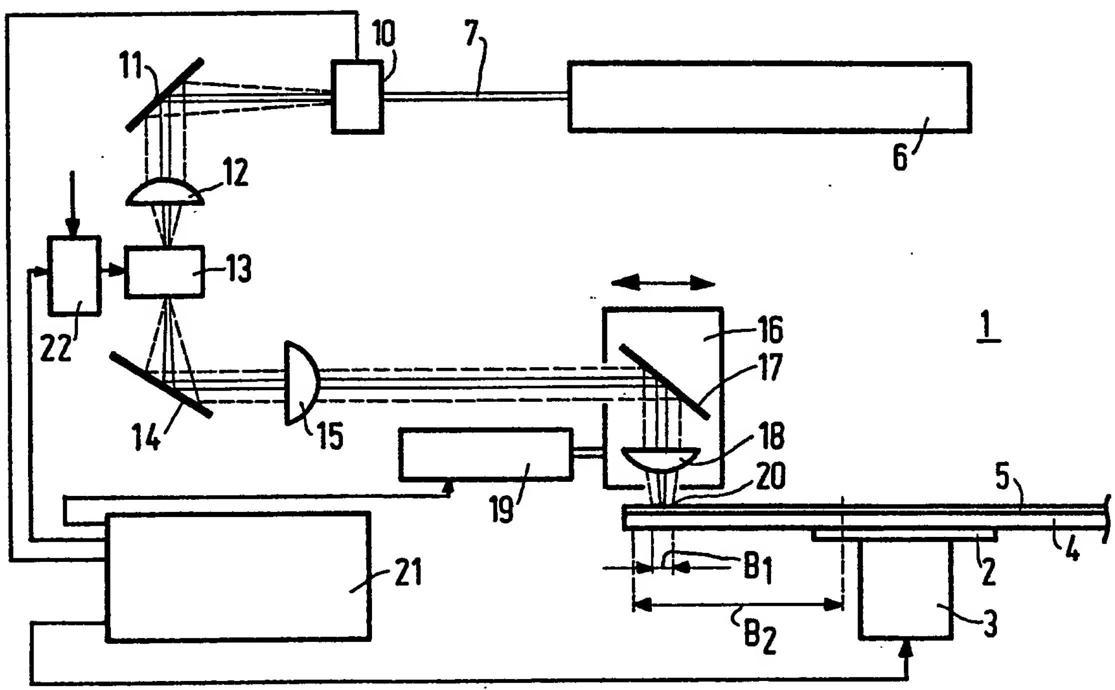

FIG.1

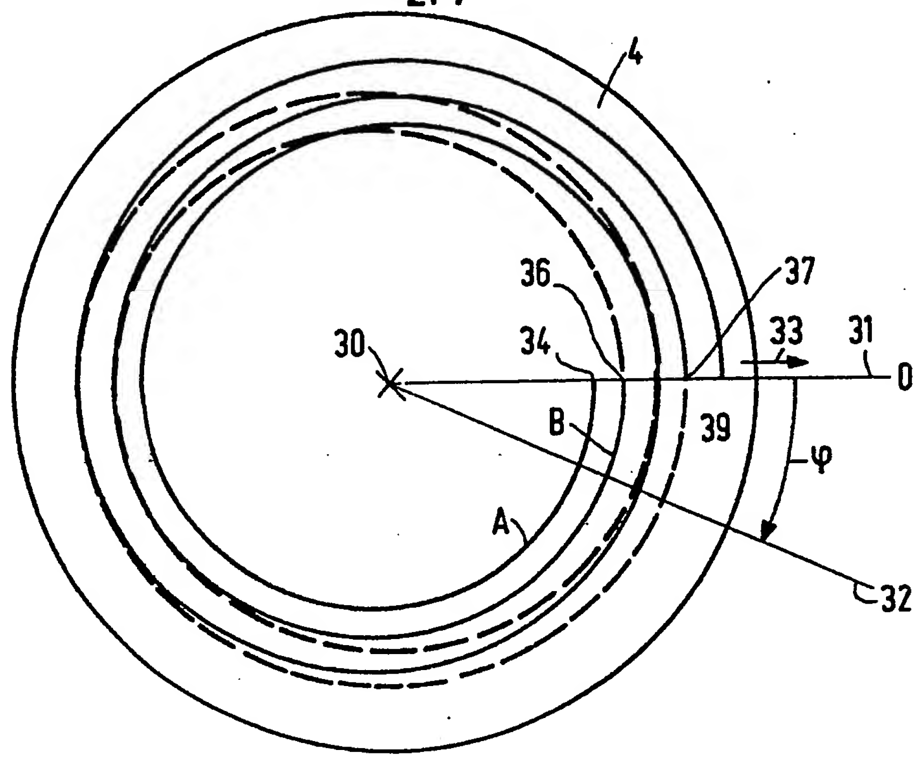
4
36
37
30
34
33
31
0
B
39
φ
A
32

FIG.2

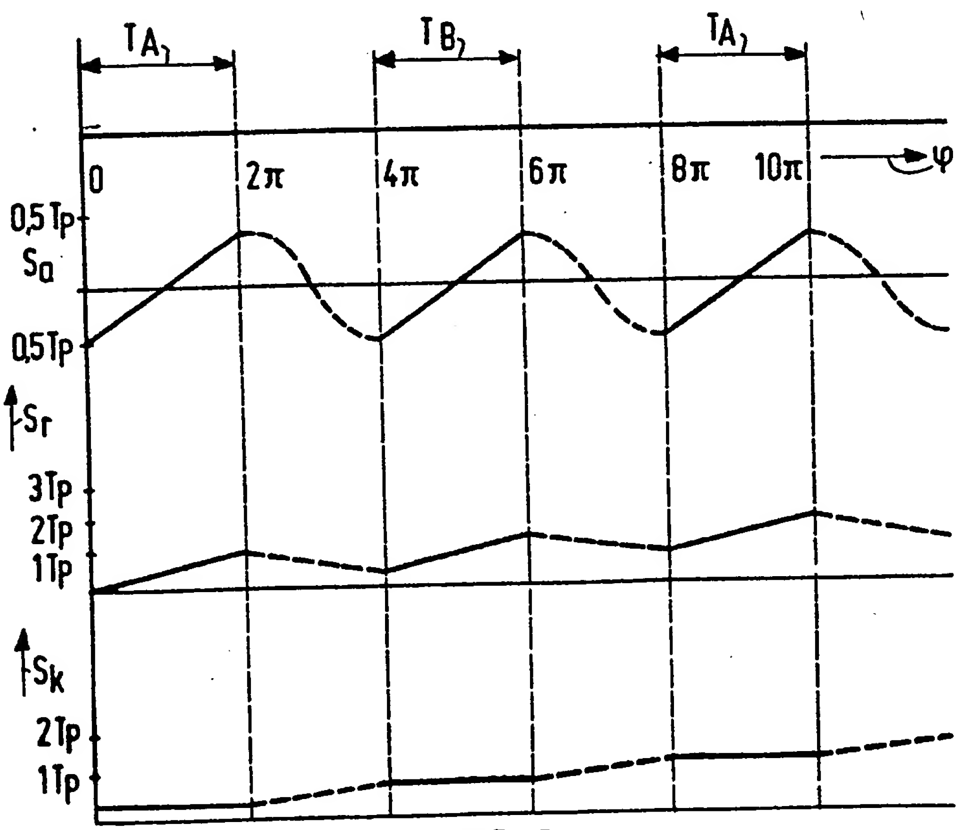
TA
TB
TA
0
2π
4π
6π
8π
10π
φ
0,5Tp
Sa
0,5Tp
Sr
3Tp
2Tp
1Tp
Sk
2Tp
1Tp

FIG.2a

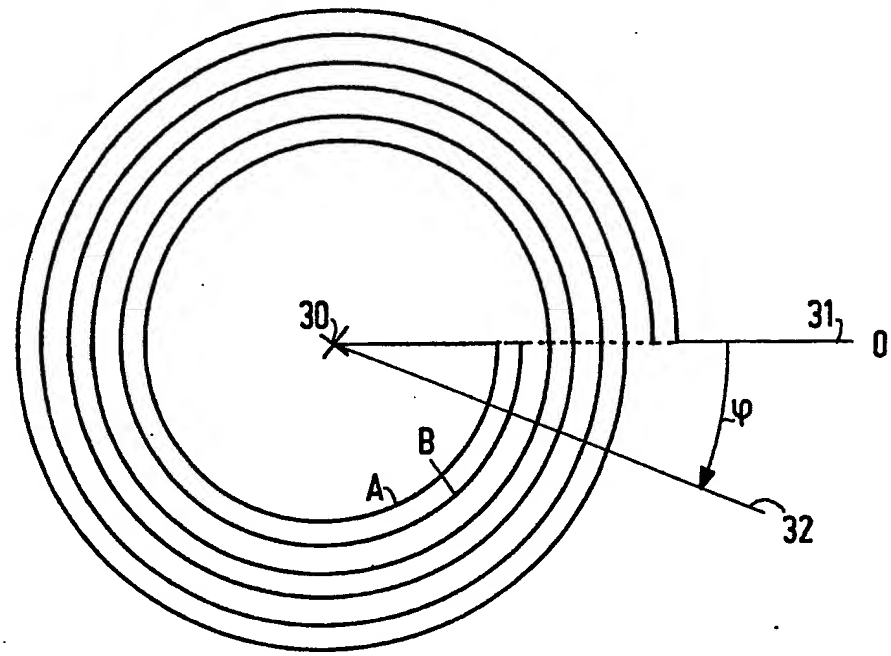
30
31
0
φ
B
A
32

FIG.3

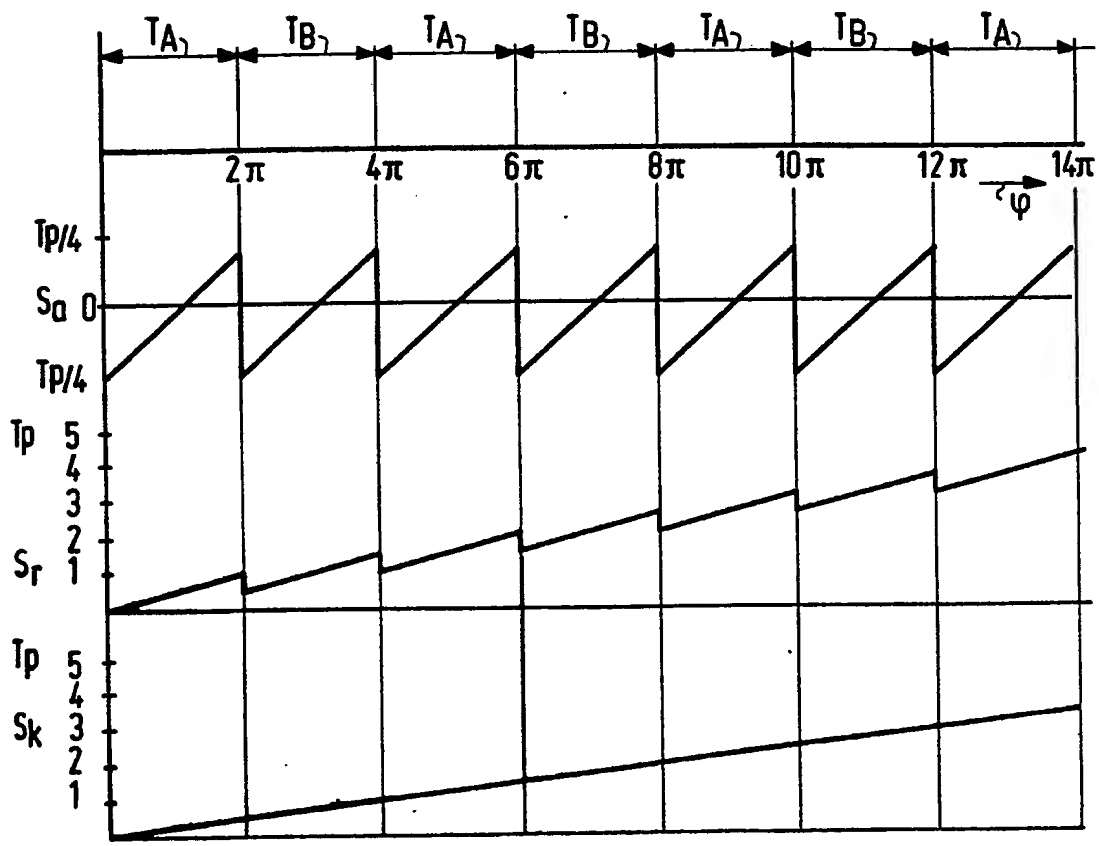
TA
TB
TA
TB
TA
TB
TA
2π
4π
6π
8π
10π
12π
14π
φ
Tp/4
Sa 0
Tp/4
Tp 5
4
3
2
Sr 1
Tp 5
4
Sk 3
2
1

FIG.3a

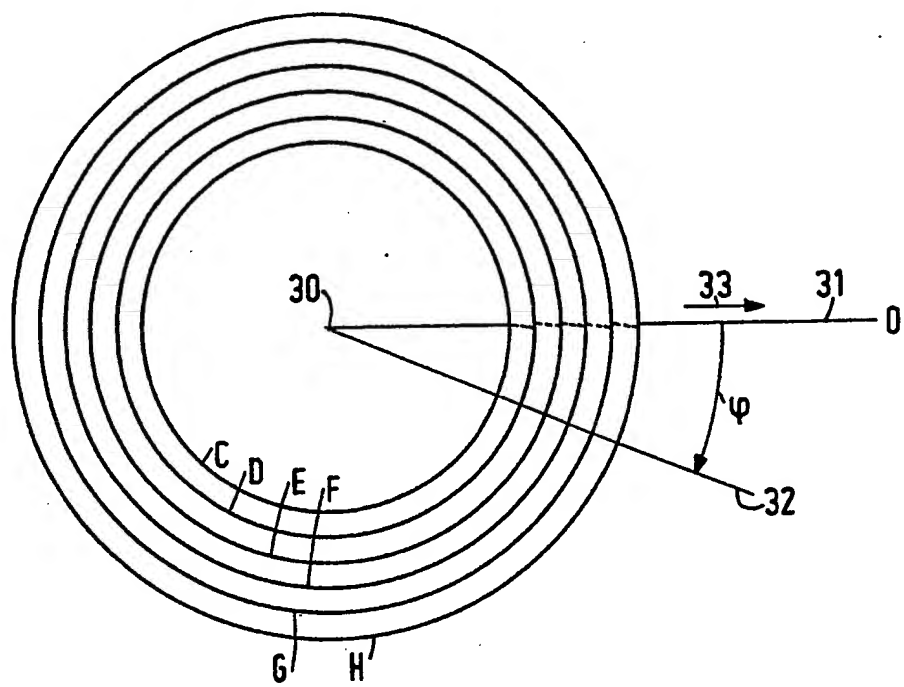
30
33
31
0
φ
32
C
D
E
F
G
H

FIG.4

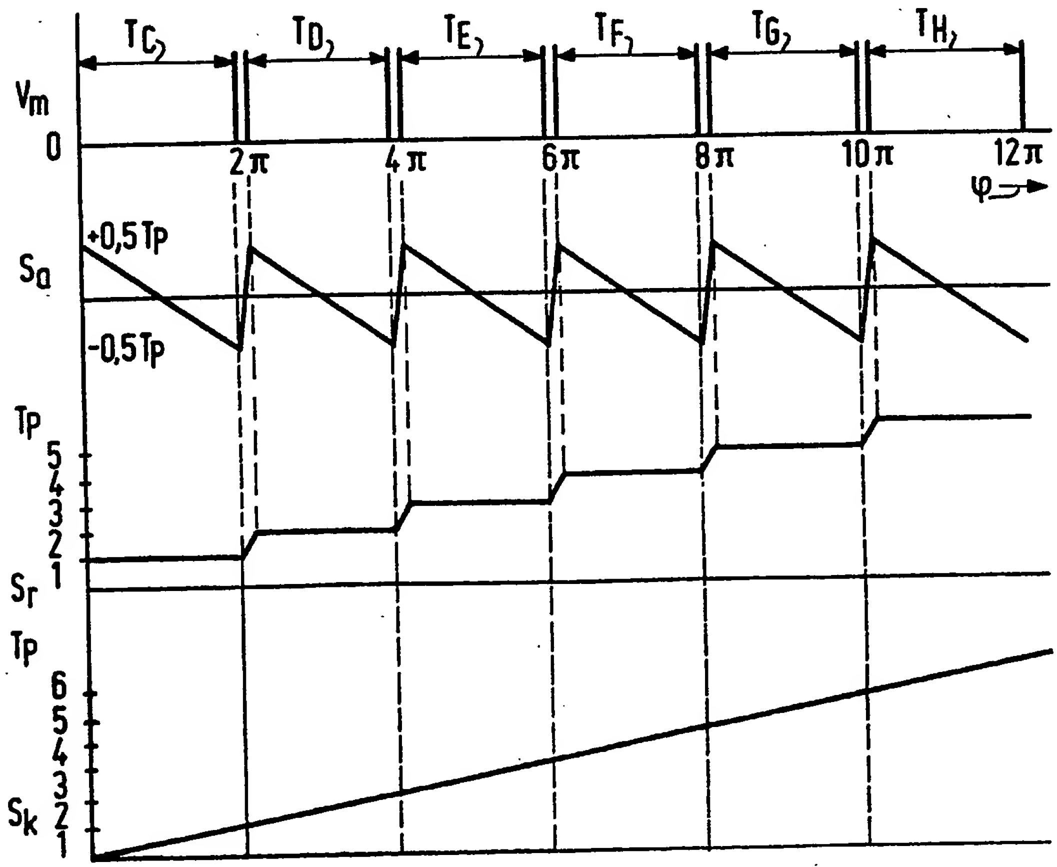
TC
TD
TE
TF
TG
TH
Vm
0
2π
4π
6π
8π
10π
12π
φ
Sa
+0,5Tp
-0,5Tp
Tp
5
4
3
2
Sr
1
Tp
6
5
4
3
Sk
2
1

FIG.4a

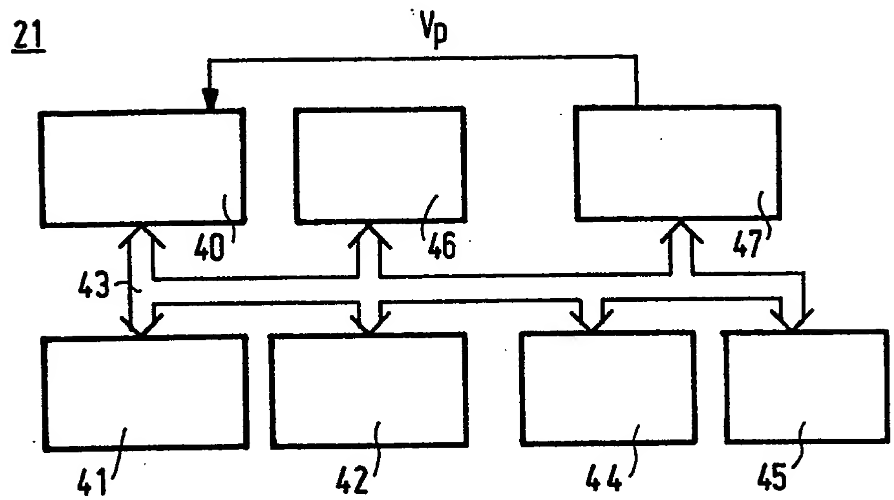

FIG.5

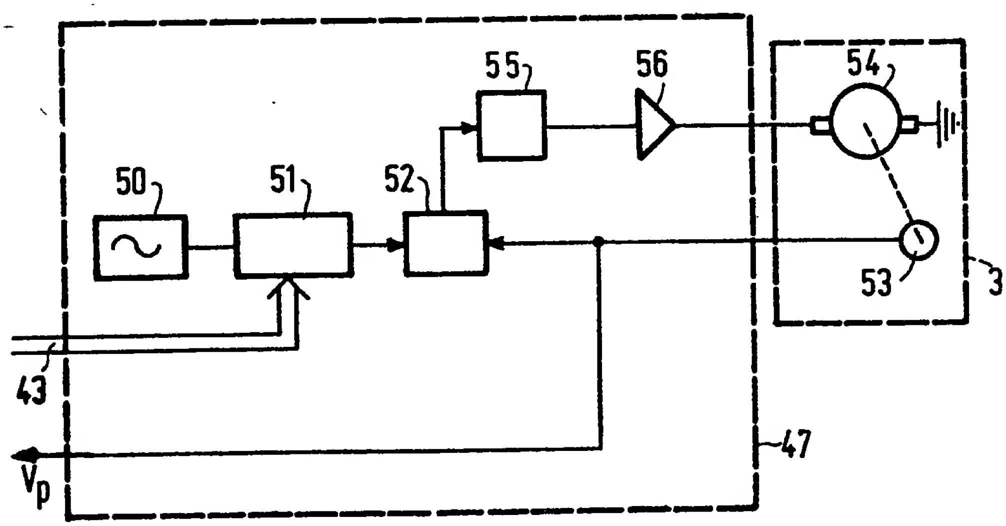

FIG.6

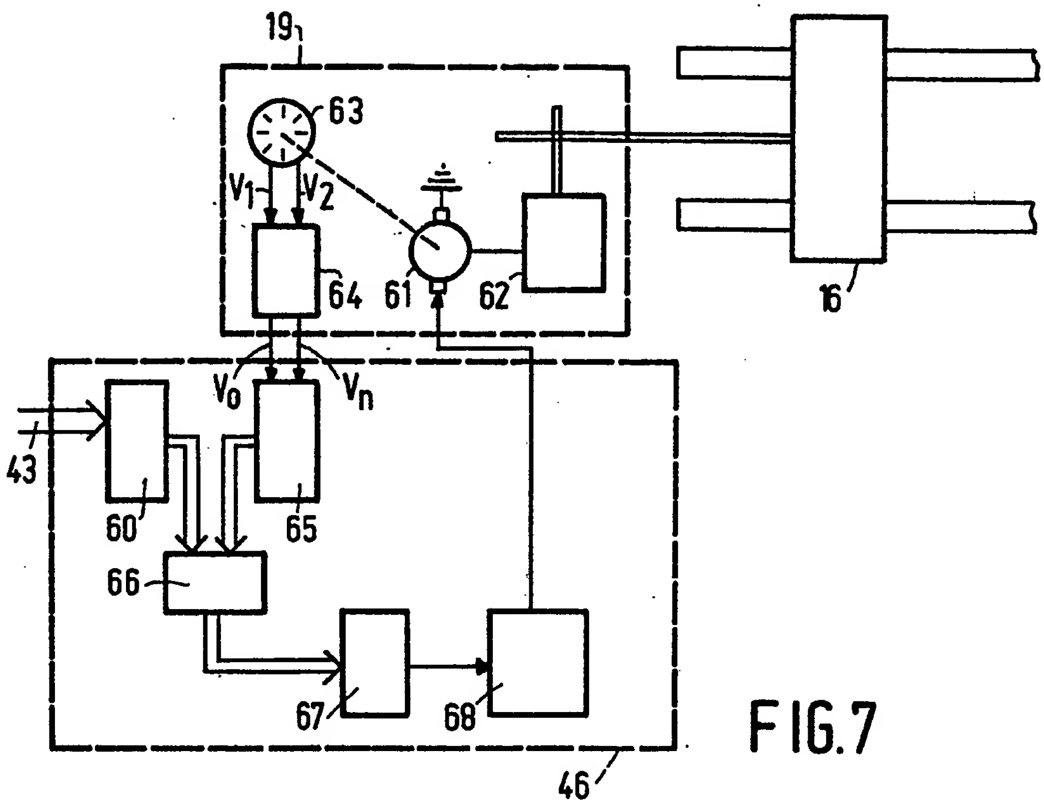

FIG.7

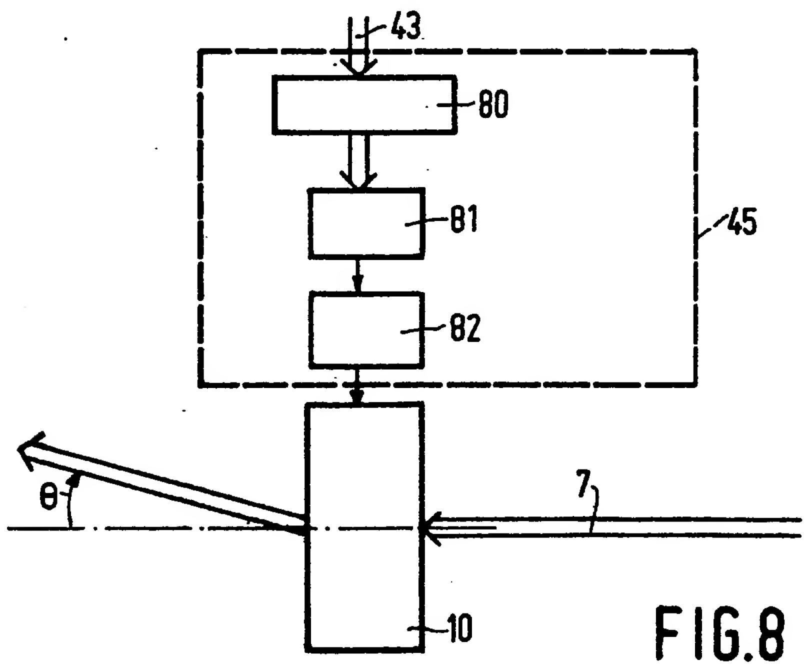

FIG.8

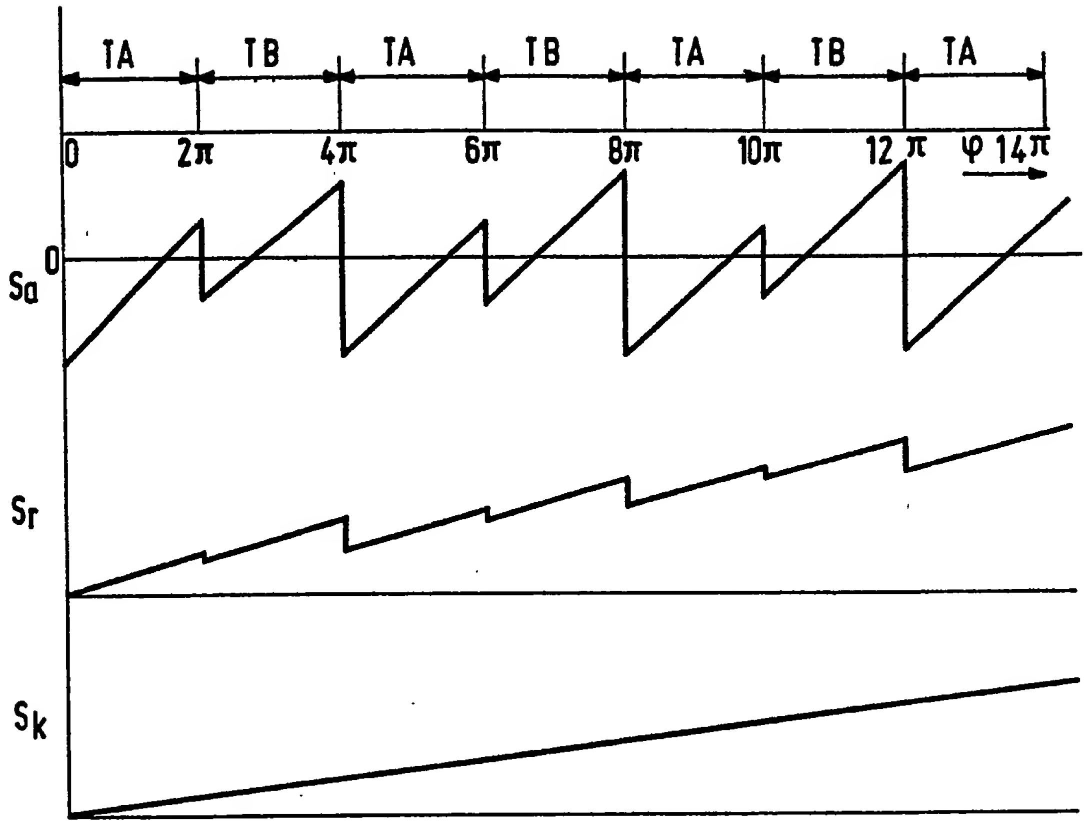

FIG.9a

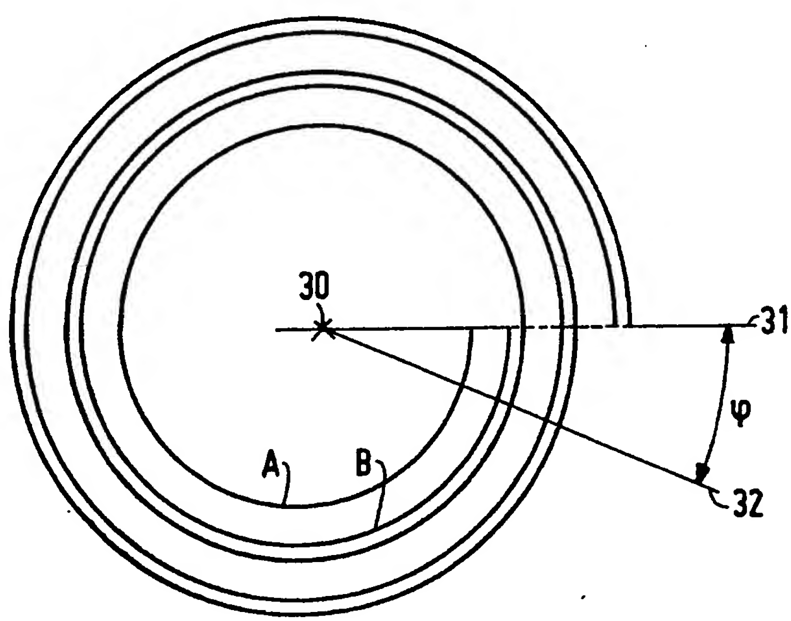

FIG.9b

0244005

European Pat nt Office

EUROPEAN SEARCH REPORT

Application number

EP 87 20 0665

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	US-A-3 908 076 (BROADBENT) * Column 2, lines 35-61; column 3, lines 12-19,33-41; column 4, line 65 - column 8, line 5; column 9, lines 28-63 *	1,2,9	G 11 B 7/007 G 11 B 23/00 G 11 B 7/26
Y		10,11	
A		5,6	

Y	US-A-4 223 347 (BOUWHUIS et al.) * Column 5, line 62 - column 6, line 48 *	10	
A		1,9	TECHNICAL FIELDS SEARCHED (Int. Cl.4)

Y	FR-A-2 312 087 (N.V. PHILIPS' GLOEILAMPENFABRIEKEN) * Page 8, line 37 - page 16, line 24 *	10,11	G 11 B H 04 N
A		1,9	

A	EP-A-0 055 439 (MATSUSHITA ELECTRIC INDUSTRIAL CO. LTD) * Page 32, lines 14-22; page 37, line 2 - page 38, line 6; figures 1,22; claim 9 *	1,3,6, 9	
	--- -/-		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24-07-1987	DAALMANS F.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken al ne
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published n, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member f the same patent family, corresponding document

EPO Form 1503 03.82

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 87 20 0665

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	FR-A-2 464 608 (MCA - DISCOVISION INC.) * Page 1, lines 6-25; page 13, lines 2-21; figure 1 * ---	1,2,6, 9	
A	US-A-3 894 179 (JACOBS et al.) * Whole document * & NL-A-7 212 045 (Cat. D,A) ---	1,2,9	
Y	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 135 (P-457)[2192], 20th May 1986; & JP-A-60 256 926 (HITACHI SEISAKUSHO K.K.) 18-02-1985 * Abstract *	10	
A	Idem -----	1-3,9	TECHNICAL FIELDS SEARCHED (Int. Cl.4)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24-07-1987	DAALMANS F.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

(19) Eur päl ches Patentamt
European Patent Office
Office uropéen d s brevets

(11) Publication number : 0 244 005 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification : 24.07.91 Bulletin 91/30

(51) Int. Cl.^{5} : G11B 7/007, G11B 23/00, G11B 7/26

(21) Application number : 87200665.5

(22) Date of filing : 08.04.87

(54) Method of scanning a radiation-sensitive recording surface of a rotating disc-shaped carrier by means of a modulated radiation beam and optical write apparatus for carrying out the method.

(30) Priority : 21.04.86 NL 8601006

(43) Date of publication of application : 04.11.87 Bulletin 87/45

(45) Publication of the grant of the patent : 24.07.91 Bulletin 91/30

(84) Designated Contracting States : DE FR GB NL SE

(56) References cited :
EP-A- 0 055 439
FR-A- 2 312 087
FR-A- 2 464 608
US-A- 3 894 179
US-A- 3 908 076
US-A- 4 223 347
PATENT ABSTRACTS OF JAPAN, vol. 10, no. 135 (P-457)[2192], 20th May 1986; & JP-A-60 256 926 (HITACHI SEISAKUSHO K.K.) 18-02-1985
SPIE conference vol 529, pp 62-68

(73) Proprietor : N.V. Philips' Gloeilampenfabrieken
Groenewoudseweg 1
NL-5621 BA Eindhoven (NL)

(72) Inventor : Hamer, René Hendrik
c/o INT. OCTROOIBUREAU B.V. Prof. Holstlaan 6
NL-5656 AA Eindhoven (NL)
Inventor : Pasman, Johannes Hermanus Theodorus
c/o INT. OCTROOIBUREAU B.V. Prof. Holstlaan 6
NL-5656 AA Eindhoven (NL)

(74) Representative : Beckers, Hubertus Franciscus Maria et al
INTERNATIONAAL OCTROOIBUREAU B.V.
Prof. Holstlaan 6
NL-5656 AA Eindhoven (NL)

EP 0 244 005 B1

D scription

The invention relates to a m thod for scanning a radiation-sensitive recording surface of a rotating disc-shaped carrier along n fold spiral paths, with n ≧ 2, by means of a modulated radiation beam which is aimed at a target point on the record carrier, the target point being moved over the recording surface in a radial direction in accordance with a predetermined motion by means of a first actuating device.

The invention also relates to an optical write apparatus comprising a drive means for rotating a disc-shaped carrier having a radiation-sensitive recording surface, an optical system for directing a radiation beam at a target point on the recording surface, and a first actuating device for moving the target point in radial direction within a first displacement range, and means for controlling the first actuating device to create a first motion component of the target point which motion is not reversed.

Such method and apparatus are known from the Reprints from SPIE, Vol. 529, page 62-68.

This document discloses a method and apparatus for the manufacture of master discs to be used for the production of preformatted recordable optical data storage discs with an optical detectable structure arranged along a two fold spiral.

This structure comprises a first sub spiral in the form of an information track comprising sector headers. Each winding of this sub spiral are located in the middle between two windings of a second sub spiral in the form of a spiral shaped pregroove. The master disc can be obtained by means of a single spot mastering apparatus in which a disc-shaped carrier with a recording surface in form of a photo resistive layer is scanned by a single recording beam along a path corresponding to the two fold spiral. This can be done by first scanning the recording surface along one of the sub spirals (for example the sub spiral defined by the pregroove) and subsequently scanning the recording surface along the other sub spiral defined by the information track, which requires a reversal of the radial direction of movement. As a result of hysteresis which is caused by backlash and the like and which result from the direction reversal in the actuating device an accurate positioning of the starting point of the second scan between the turns of the first sub spiral already scanned is not possible. This presents a serious problem, in particular, in the manufacture of masters, where extremely stringent requirements are imposed on the positional accuracy ($\pm 20.10^{-9}$ m) of the second sub spiral relative to the first sub spiral.

It is the object of the invention to provide a method and apparatus of the type defined in th opening paragraphs, which mitigat the aforementioned drawbacks.

For the method this bject is achieved in that a second actuating device is employed in order to obtain a composite motion of the target point, which motion is composed of a first and a second radial motion compon nt produced by th first and the second actuating d vice respectively, the first and the second actuating device being controlled in such a way that the first motion component is a predetermined motion whose direction is not reversed and the second motion component is a predetermined reciprocating motion, the exposure of the recording surface to the radiation beam being interrupted at least during return of the reciprocating motion, in a cycle corresponding to n consecutive reciprocating motions during the consecutive forward portions of said motions the recording surface being each time scanned along an integral number g (including 1) of turns of a sub spiral, for which purpose the velocities of the first and the second motion component during the forward portions are selected in such a way that the velocity of the composite motion is substantially proportional to the angular velocity of the carrier and for which purpose the velocities of the motion components during the return portions are selected in such a way that the target point is transferred to the point where scanning along the following sub spiral has been interrupted.

For the apparatus this object is achieved in that the optical write apparatus comprises a second actuating device for radially moving the target point over the recording surface within a second displacement range smaller than the first displacement range, so as to create a composite position of the target point, means for controlling the second actuator to create a reciprocating motion component, such that in a cycle corresponding to n consecutive reciprocating motions during the consecutive forward portions of the reciprocating motion the recording surface is each time scanned along an integral number g (including 1) of turns of a sub spiral, and during the forward portions of the reciprocating motion the velocity of the composite motion is substantially proprotional to the angular velocity of the carrier, and that during the return portions of the reciprocating motion the target point is transferred to the point where scanning along the following sub spiral has been interrupted.

In the method and apparatus according to the invention an accurate movement is obtained because the non-reversing motion component ensures that hysteresis in the first actuating device, which is difficult to keep within the specified tolerances on account of the large displacement range, has no influence the accuracy. Moreover, a non-reversing motion produces less undesired vibrations. The reversal of the direction of the target point, which is inevitable when scanning along multiple spiral, is now obtained by means of an actuating device with a small displacement rang . In th cas of an actuating device having a small rang the hystereses can be kept within the required tolerances in a comparatively simple manner. Moreover, the undesired vibrations caused by the

reciprocating motion are smaller.

At this place it is to be remarked that US 3.908.076 discloses an optical recording method and apparatus for recording concentric track structure on a disc-shaped record carrier. A recording radiation beam is aimed to a target point in the recording surface of the rotating record carrier. The radial position of the target point is set by means of a coarse positioning actuator and a fine position actuator, so as to obtain a composite motion of the target point. The first actuator is controlled to create a first motion which is not reversed. The second actuator has a smaller displacement range than the first actuator and is controlled to create a predetermined reciprocating motion.

The controlling of the actuators is such that subsequently concentric paths on the record carrier are scanned with the recording beam. In the time intervals between the scanning of the concentric path the recording is interrupted.

In one embodiment the optical write apparatus is characterized in that the second actuating device is acousto-optical actuating device for deflecting the radiation beam which is aimed at the recording surface.

The absence of mechanical components in the acousto-optical modulator results in a very accurate yet almost vibration-free reciprocating motion.

Embodiments of the invention will now be described in more detail, by way of example, with reference to figures 1 to 8, in which

Fig. 1 shows an optical write apparatus in accordance with the invention,

Figs. 2, 3 and 9 show a number of paths described by the target point to explain the inventive method,

Figs. 2a, 3a represent the motion components then produced by the first and the second actuating device and the target point motion composed of these components as a function of the angular displacement of the carrier,

Figs. 4 and 4a show concentric paths not forming part of the invention,

Fig. 5 shows an example of the control device of the optical write apparatus, and

Figs. 6, 7 and 8 show parts of the control device.

Fig. 1 shows an optical write apparatus 1 in accordance with the invention. The write apparatus 1 comprises a turntable 2 which is rotated by a drive means 3. A disc-shaped carrier 4 provided with a light-sensitive layer 5, for example a photo-resist layer, can be placed on the turntable 2.

A laser 6 emits a light beam 7 which is projected onto the light-sensitive layer 5. The light beam 7 is first passed through a deflection device 10. The deflection device 10 is of a type by means of which a light beam can be deflected very accurately within a small range. Suitably, th deflection device is an acousto-optical modulator. However, it is also possible to use other deflection devices, such as for example a mirror which is pivotable through a small angle. The limits of the deflection range are indicated in broken lines in Fig. 1. Th light beam 7 deflected by the deflection device 10 is directed to an optical head 16 via a mirror 11, a lens 12, a modulation device 13 for modulating the light beam 7, a mirror 14 and a lens 15. The optical head comprises a mirror 17 and an objective 18 for focussing the light beam on the light-sensitive layer 5. The optical head is radially movable reltive to the rotating carrier 4 by means of a positioning device 19.

By means of the above optical system the light beam 7 is aimed at a target point 20 on the light-sensitive layer 5, the position of this target point 20 being determined by the magnitude of the deflection of the light beam 7 produced by the deflection device 10 and the radial position of the write head 16 relative to the carrier 4. In the shown position of the optical head 16 the target point 20 can be moved by means of the deflection device 10 within a range indicated by B1. For the deflection shown the target point can be moved over a range designated B2 by moving the optical head 16. Further, the optical write apparatus comprises a modulation generator 22 for generating a modulation signal for the modulation device 13. Moreover, the optical write apparatus 1 comprises a control device 21 which, for controlling the motion of the target point 20, is coupled to the deflection device 10, the positioning device 19 and the actuating device 19 and which control device is coupled to the modulation generator 22 in order to synchronize the modulation signal with the motion of the target point 20 over the light-sensitive layer 5.

By means of the optical write apparatus 1 the photoresist layer 5 can be scanned with the light beam 7 along a multiple spiral, so that information can be recorded along a multiple spiral.

Fig. 2 shows an example of the path which may be described by the target point 20. The centre of rotation about which the disc-shaped carrier 4 is rotated is indicated by the reference numeral 30. The path which may be followed by the target point 20 in a radial direction is designated 31. The angle between the path 31 and a radius 32 issuing from the centre of rotation 30 and situated on the record carrier 4 is designated φ. The sub-spirals A and B together constitute the two-fold spiral along which the information to be recorded should be arranged. During a first revolution of the carrier 4 ($0 < \varphi < 2\pi$) the target point is moved from a position 34 in a radial direction indicated by the arrow 33 with a velocity proportional to the circumferential velocity of the carrier 4, so that the target point 20 follows a spiral path on the carrier 4. In Fig. 2a the corresponding radial displacement Sr is plotted as a function of φ. After one revolution th target point has reached a position 35, after which th target point 20 is returned over a distance corresponding to half the track pitch Tp during th next

revolution ($2\pi < \varphi < 4\pi$), so that at the end of the second revolution the target point 30 has reached a position 36. Subsequently, during the next revolution ($4\pi < \varphi < 6\pi$) th target point 20 is again moved in the direction indicated by the arrow 33 with a velocity proportional to the angular velocity, so that the light-sensitive layer 5 of the carrier 4 is scanned along the first turn of the sub-spiral B.

When the target point 20 has reached the end 37 of the first turn of the sub-spiral B the target point is returned in a radial direction during one revolution ($6\pi < \varphi < 8\pi$) until position 35 is reached, to effect scanning along the second turn of the sub-spiral. A. In this way the photoresist layer 5 can be scanned alternately along the turns of the sub-spiral A and the turns of the sub-spiral B, the light beam 7 being modulated in conformity with the information to be recorded during the time intervals TA and TB (in which the photoresist layer is scanned along the sub-spiral A and the sub-spiral B respectively). During the time interval in which the target point is moved from one sub-spiral to an other (indicated by a broken line in Fig. 2), the light beam 7 is interrupted by the modulation device 13, so that no recording is effected. It will be appreciated that for moving the target point from one sub-spiral to another sub-spiral any path is permissible whose end point corresponds to the desired starting point of the next scan. The radial displacement Sr is partly determined by a displacement component Sk produced by the positioning device 19 and a displacement component Sa produced by the deflection device 10. In Fig. 2a Sk and Sa are also plotted as a function of φ. As is apparent from Fig. 2a, the target point 20 performs a radial motion which is composed of a motion component whose direction is not reversed and which is determined by the variation of the displacement component Sk and of a reciprocating motion component which is determined by the variation of the displacement component Sa.

Since the direction of the motion component produced by the positioning device 19 is not reversed hysteresis in the positioning device 19 does not affect the positioning accuracy of the target point 20. Tne reversal of the direction of the radial motion of the target point 20, which is inevitable when scanning the two-fold spiral, is obtained by means of the reciprocating motion component produced by the scanning device 10. Since the range B1 of the deflection device 10 is small relative to the displacement range B2 of the optical head, the inaccuracy caused by hysteresis is much easier to be kept within the required tolerances for the deflection device 10, thus ensuring an accurate positioning of the target point 20. When an acousto-optical deflection device is employed a very accurate positioning is possibl owing to the absence of mechanical components.

Moreover, the use of an acousto-optical deflection device enables very rapid radial displacements of the target point 20 to be obtained, so that after scanning one turn of a sub-spiral it is possibl to return almost immediately to th point where scanning of the other spiral was interrupted. The path described by the target point and the associated variation of Sr, Sa and Sk are illustrated in Fig. 3 and Fig. 3a respectively.

The path followed by the target point 20 when changing over from scanning one spiral to scanning of the other spiral is represented in broken lines in Fig. 3. Since the radial displacement of the target point cannot be performed in an infinitely short time the turns of the sub-spirals will not be entirely contiguous. However, these errors are so small that this presents no problem for most uses.

Figs. 9a and 9b show another variant of the inventive method where the turns of each of the two sub-spirals are not situated exactly at half the distance between two consecutive turns of the other sub-spiral, but for example at 1/4 of this distance.

In the foregoing scanning along a two-fold spiral has been illustrated. However, it will be evident to those skilled in the art that in the similar way scanning along a multiple spiral comprising more than two sub-spirals can be effected.

In the scanning method described above the radial position of the target point 20 is controlled in such a way that alternately portions of one sub-spiral and portions of the other sub-spiral are scanned, the target point, after scanning of a portion of one sub-spiral, returning to the point where scanning of the other sub-spiral was interrupted. In the present example the lengths of the alternately scanned portions of the sub-spirals correspond to the length of one turn. It will be appreciated that, in principle, any arbitrary length is permissible, provided that when the scanning of one sub-spiral is interrupted scanning proceeds at the point where the scanning of the other sub-spiral was interrupted.

Further, it will be evident that S and Sk can be varied in numerous ways. In this respect it is only important that the displacement of the target point proceeds in a desired manner and that the direction of the motion component determined by Sk is not reversed. An accurate radial motion of the target point 20 is then always guaranteed.

Fig. 4 shows the paths followed by the target point when the light-sensitive layer 5 is scanned along concentric tracks. Fig. 4a illustrates the associated variation of Sr, Sa and Sk as a function of φ.

When concentric paths C, D, E, F, G and H are scanned the displacement component Sk is fully compensated for by the displacement component Sa, so that Sr remains constant when concentric tracks are scanned. After every complete revolution of the carrier 4 the target point 20 is moved over a distance corresponding to th track pitch Tp by means of the deflection device 10. For th giv n variation of Sk the

optical head is m ved with a substantially constant velocity, resulting in a substantially vibration-free movement of the optical head. The velocity changes in the velocity of the radial motion of the target point are obtained by means of the acousto-optical deflection device 10, which is almost vibration-free, so that a very rapid and substantially vibration-free motion of the target point from one concentric track to the other is obtained, enabling the recording process to be started rapidly owing to tne absence of a waiting time after a displacement.

In the method of scanning the photoresist layer along concentric paths as described herein, the variation of Sk and the variation of Sa are such that the resulting velocities are proportional to the circumferential velocity of the carrier 4. It will be evident that Sa and Sk can be varied in numerous ways. In this respect it is merely important that the displacement of the target point proceeds in the desired manner and that the motion determined by Sk is a non-reversing and uniform motion. In this way an accurate and substantially vibration-free motion of the target point is then always guaranteed.

Fig. 5 shows a block diagram of the control device 21. The control device 21 comprises a programmable computing unit comprising a central processing unit 40 (CPU), a read-only memory 41 (ROM) and a random-access memory 42 (RAM). The memories 41 and 42 are connected to the central processing unit 40 in the customary manner via a bus 43. A control unit 44 for controlling the modulation generator 22, a control unit 45 for controlling the deflection device 10, a control unit 46 for controlling the positioning device 19, and a control unit 47 for controlling the drive means 3 are also coupled to the central processing unit 40 via the bus 43.

Fig. 6 shows the control unit 47 in detail. The control unit 47 comprises an oscillator 50 for generating clock pulses of constant frequency, which are applied to a frequency divider 51 of a programmable type, whose divisor is adjustable by the central processing unit 40 via the bus 43. The output of the diviser 51 is applied to an input of a first-detection circuit 52. The output signal of a pulse generator 53 is applied to the other input of the phase-detection circuit 52, which pulse generator is mounted on the shaft of a motor 54 for driving the turntable 2 and is constructed in such a way that it generates a pulse signal Vp of a frequency which is proportional to the speed of the motor 54. The output signal of the phase-detection circuit 52, which is representative of the phase difference between the signal on its inputs, is applied to a control circuit 55 which depending on the phase difference generates a control signal which is applied t a power amplifier 56 for energizing th motor 54.

The phase-detection circuit 52, the control circuit 55, the amplifier 56, the motor 54, and the pulse generator 53 together constitut a phase-locked loop of a customary type for controlling the circumferential speed of the turntable 2 with a velocity which is proportional to the frequency of the output signal of the programmabl frequency divider 51. The output signal Vp of the pulse generator 53 is applied to an input of the central processing unit 40.

Fig. 7 shows an example of the control unit 46 for controlling the positioning device 19. The control unit 46 forms part of a control system for controlling the position of the optical head 16 in conformity with a desired value which in the form of a digital code can be loaded by means of the central processing unit 41 into a register 60 connected to the bus 43. The control system comprises a motor 61 for moving the optical head 61 via a reduction mechanism 62. A pulse generator 63 is coupled to the shaft to the motor 61. The pulse generator 63 is of a type generating two pulse-shaped signals V_1 and V_2 which are 90° or 270° phase-shifted relative to each other depending on the direction of rotation of the motor and which have frequency which is proportional to the speed of the motor 61. These signals V_1 and V_2 are applied to a circuit 64 which derives signals V_o and V_n from the signals V_1 and V_2 in such a way that pulses of V_o are generated if the motor rotates in one direction and pulses of V_n are generated if the motor rotates in the other direction.

The signals V_o and V_n are applied to respectively the count-up input and the count-down input of an up-/down counter 65. By means of a difference circuit 66 the count of the counter 65, which is a measure of the position of the optical head 16, is compared with the desired position stored in encoded form in the register 60. The output signal of the difference circuit is applied to a digital-to-analog converter 67. The output signal of the digital-to-analog converter 67 is applied to an input of a control circuit. 68. The control circuit 68 derives such an energizing signal for the motor 71 from the output signal of the analog-to-digital converter 67 that the position of the optical head is in conformity with the desired values stored in tne register 60.

Fig. 8 shows an example of the control unit 45 for controlling the deflection device 10. The control circuit 45 comprises a register 80 into which a digital code can be loaded by the central processing means 40 via the bus 43. A digital-to-analog converter 81 converts the digital code into an analog signal which serves as a control signal for a voltage-controlled oscillator 82 of the customary type. The output signal of the oscillator 82 is applied to the control input of the acoust-optical deflection device 10 of a conventional type, a light beam 7 passed through the deflection device being d fl cted through an angle θ d termined by the frequency of the signal on th control input.

By means of the control device described herein the angular velocity the carrier, the radial displacement Sa of the target point 20 produced by the deflec-

tion device 10, and the radial displacement Sk of th target point produced by the positioning device 19 are controlled in conformity with a predetermin d pattern during scanning of th photoresist layer 5. For this purpose the control device 21 is controlled by a program stored in the read-only memory 41. When this program is performed the central processing unit 40 determines the angular spacing φ by counting the number of pulses of the signal V_p which it receives. Upon any variation of the number of pulses counted the central processing unit 40 adapts the contents of the registers 60 and 81 in order to bring the displacement Sa produced by the deflection device 10 and the displacement Sk produced by the positioning device 19 in conformity with the desired values corresponding to the specific angular spacing φ, as is illustrated for example in Figs. 2a, 3a and 4a. These desired values can be stored in one of the memories 41 or 42, for example in the form of a look-up table. However, if there is a simple relationship (as in Figs. 2a, 3a and 4a) between the displacements Sa and Sk and the angular spacing φ the desired values can be computed simply by the central processing unit 40. The central processing unit 40 also controls the synchronisation of the modulation signal with the motion of the target point over the light-sensitive layer 51. As this synchronisation falls beyond the scope of the present invention, it will not be described in more detail.

The control device 21 described herein is constructed by means of a programmable computing unit. However, it will be evident that the control device can also be constructed by means of a "hard-wired" circuit.

The embodiment described herein employs an acousto-optical deflection device. It will be obvious to those skilled in the art that it is equally possible to utilize an electro-optical deflection device.

Claims

1. A method of scanning a radiation-sensitive recording surface of a rotating disc-shaped carrier (5) along n fold spiral paths, with n ≧ 2, by means of a modulated radiation beam which is aimed at a target point on the record carrier, the target point being moved over the recording surface in a radial direction in accordance with a predetermined motion by means of a first actuating device (16), characterized in that a second actuating device (10) is employed in order to obtain a composite motion of the target point, which motion is composed of a first and a second radial motion component produced by the first and the second actuating device respectively, the first and the second actuating device being controlled in such a way that the first moti n component is a predetermined motion whose direction is not reversed and the second motion component is a predetermined reciprocating motion, the exposure of the recording surface to th radiation beam being interrupted at least during return of the reciprocating motion, in a cycle corresponding to n consecutive reciprocating motions during the consecutive forward portions of said motions the recording surface being each time scanned along an integral number q (including 1) of turns of a sub spiral, for which purpose the velocities of the first and the second motion component during the forward portions are selected in such a way that the velocity of the composite motion is substantially proportional to the angular velocity of the carrier and for which purpose the velocities of the motion components during the return portions are selected in such a way that the target point is transferred to the point where scanning along the following sub spiral has been interrupted.

2. A method as claimed in Claim 1, characterized in that the duration of one period of the second reciprocating motion component substantially corresponds to p revolutions, p being an integer larger than or equal to q, the velocities of the first and the second motion components during the forward portions of the second motion component being elected in such a way that the velocity of the composite motion is substantially proportional to the angular velocity of the carrier during an uninterrupted time interval which at least corresponds to q revolutions, and the target point being moved in a radial direction over a distance substantially corresponding to 1/n times the pitch of the n fold spiral during one full period of the reciprocating motion component.

3. A method as claimed in Claim 2, characterized in that the first motion component is substantially zero during the forward portion of the second motion component.

4. A method as claimed in Claim 2, characterized in that the velocity of the first motion component is substantially proportional to the angular velocity of the carrier.

5. A method as claimed in Claim 2 or 3, characterized in that p is equal to q.

6. A method as claimed in Claim 1, 2 or 3, characterized in that n is two.

7. An optical write apparatus for carrying out the method as claimed in one of the Claims 1 to 6, comprising a drive means (3) for rotating a disc-shaped carrier (5) having a radiation-sensitive recording surface, an optical system for directing a radiation beam at a target point on the recording surface, and a first actuating device (16) for moving the target point in radial direction within a first displacement range, and means for controlling the first actuating device to creat a first motion component f the target point which motion is not reversed, characterized in that the optical write apparatus comprises a second actuating device (10) for radially moving the target point over the recording surfac within a second displacement

range smaller than the first displac ment range, s as to create a composite positi n of th targ t point, means for controlling th second actuator to create a reciprocating motion component, such that in a cycle corresponding to n consecutive reciprocating motions during the consecutive forward portions of the reciprocating motion the recording surface is each time scanned along an integral number g (including 1) of turns of a sub spiral, and during the forward portions of the reciprocating motion the velocity of the composite motion is substantially proprotional to the angular velocity of the carrier, and that during the return portions of the reciprocating motion the target point is transferred to the point where scanning along the following sub spiral has been interrupted.

8. An optical write apparatus as claimed in Claim 7, characterized in that the second actuating device is an acousto-optical deflection device for deflecting the radiation beam which is aimed at the recording surface.

9. An optical write apparatus as claimed in Claim 7, characterized in that the second actuating device is an electro-optical deflection device.

Patentansprüche

1. Verfahren zum Abtasten einer strahlungsempfindlichen Aufzeichnungsfläche eines drehenden scheibenförmigen Trägers (5) in n gefalteten Spiralwegen, wobei n ≧ 2 ist, mittels eines auf einen Zielpunkt auf dem Aufzeichnungsträger gerichteten, modulierten Strahlungsbündels, wobei der Zielpunkt über die Aufzeichnungsfläche entsprechend einer vorgegebenen Bewegung mit Hilfe eines ersten Betätigungsgeräts (16) in einer radialen Richtung bewegt wird, dadurch gekennzeichnet, daß ein zweites Betätigungsgerät (10) zum Erhalten einer zusammengesetzten Bewegung des Zielpunktes ausgenutzt wird, wobei diese Bewegung aus einer vom ersten bzw. zweiten Betätigungsgerät erzeugten ersten und zweiten Radialbewegungskomponente zusammengesetzt ist, wobei das erste und das zweite Betätigungsgerät derart gesteuert werden, daß die erste Bewegungskomponente eine vorgegebene Bewegung ist, deren Richtung nicht umgekehrt wird, und die zweite Bewegungskomponente eine vorgegebene Reziprokbewegung ist, daß die Anstrahlung der Aufzeichnungsfläche mit dem Strahlungsbündel wenigstens bei der Rückkehr der Reziprokbewegung unterbrochen wird, in einem Zyklus entsprechend n aufeinanderfolgenden Reziprokbewegungen während der aufeinanderfolgend n Vorwärtsanteile dieser Bewegungen die Aufzeichnungsfläch jedesmal entlang ein r Integralzahl g (einschl. 1) von Windung n iner Unterspiral abgetastet wird, zu welchem Zweck die Geschwindigkeiten d r ersten und zweiten Bewegungskomponent bei d n Vorwärtsanteilen d rart gewählt werden, daß die Geschwindigkeit der zusammenges tzten Bewegung im wesentlichen proportional der Winkelgeschwindigkeit des Trägers ist, und zu welchem Zw ck di Geschwindigkeiten der Bewegungskomponenten bei den Rückkehranteilen derart gewählt werden, daß der Zielpunkt nach dem Punkt gebracht wird, in dem die Abtastung entlang der folgenden Unterspirale unterbrochen wurde.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Dauer einer Periode der zweiten Reziprokbewegungskomponente im wesentlichen p Umdrehungen entspricht, worin p eine ganze Zahl größer als oder gleich q ist, wobei die Geschwindigkeiten der ersten und zweiten Bewegungskomponenten während der Vorwärtsanteile der zweiten Bewegungskomponente derart gewählt werden, daß die Geschwindigkeit der zusammengesetzten Bewegung im wesentlichen proportional der Winkelgeschwindigkeit des Trägers während eines ununterbrochenen Intervalls ist, das wenigstens g Umdrehungen entspricht, und der Zielpunkt über einen Abstand im wesentlichen gleich 1/n-mal dem Schritt der n gefalteten Spirale in einer vollen Periode der Reziprokbewegungskomponente in einer radialen Richtung verlagert wird.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß die erste Bewegungskomponente im wesentlichen gleich Null ist während des Vorwärtsanteils der zweiten Bewegungskomponente.

4. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß die Geschwindigkeit der ersten Bewegungskomponente im wesentlichen proportional der Winkelgeschwindigkeit des Trägers ist.

5. Verfahren nach Anspruch 2 oder 3, dadurch gekennzeichnet, daß p gleich q ist.

6. Verfahren nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, daß n gleich 2 ist.

7. Optisches Aufzeichnungsgerät zur Durchführung des Verfahrens nach einem oder mehreren der Ansprüche 1 bis 6, mit einem Antriebsmittel (3) zum Drehenlassen eines scheibenförmigen Trägers (5) mit einer strahlungsempfindlichen Aufzeichnungsfläche, einem optischen System zum Richten eines Strahlungsbündels auf einen Zielpunkt auf der Aufzeichnungsfläche, und einem ersten Betätigungsgerät (16) zum Bewegen des Zielpunktes innerhalb eines ersten Bewegungsgebiets in radialer Richtung, und mit Mitteln zum Steuern des ersten Betätigungsgeräts zum Schaffen einer ersten Bewegungskomponente des Zielpunktes, wobei die Bewegung nicht umgekehrt wird, dadurch gekennzeichnet, daß das optische Aufzeichnungsgerät ein zweites Betätigungsgerät (10) zum radialen Bewegen des Zielpunktes über die Aufzeichnungsfläch innerhalb eines zweit n Bewegungsg biets, das kleiner ist als das erste Bewegungsg bi t, zum Schaffen in r zusammengesetzten Positi n des Zielpunktes und Mittel zum Steuern des zw it n Betätigungsglieds zum der-

artigen Schaffen einer Reziprokbewegungskompo- n nte, daß in inem Zyklus entsprechend n aufeinanderfolgenden Reziprokbewegungen während der aufeinanderfolgenden Vorwärtsanteil der Reziprokbewegung die Aufzeichnungsfläche jedesmal entlang einer Integralzahl g (einschl. 1) von Windungen einer Unterspirale abgetastet wird, und während der Vorwärtsanteile der Reziprokbewegung die Geschwindigkeit der zusammengesetzten Bewegung im wesentlichen proportional der Winkelgeschwindigkeit des Trägers ist, und daß während der Rückkehranteile der Reziprokbewegung der Zielpunkt nach dem Punkt gebracht wird, in dem die Abtastung entlang der folgenden Unterspirale unterbrochen wurde.

8. Optisches Aufzeichnungsgerät nach Anspruch 7, dadurch gekennzeichnet, daß das zweite Betätigungsgerät eine auf die Aufzeichnungsfläche gerichtete akustooptische Ablenkeinrichtung zum Ablenken des Strahlungsbündels ist.

9. Optisches Aufzeichnungsgerät nach Anspruch 7, dadurch gekennzeichnet, daß das zweite Betätigungsgerät eine elktrooptische Ablenkeinrichtung ist.

Revendications

1. Procédé pour balayer une surface d'enregistrement, sensible au rayonnement, d'un support rotatif en forme de disque (5), suivant des trajets en spirale n-uple, n étant ...2, à l'aide d'un faisceau de rayonnement modulé dirigé vers un point de mire sur le support d'enregistrement, le point de mire étant déplacé sur la surface d'enregistrement dans un sens radial suivant un mouvement prédéterminé, à l'aide d'un premier dispositif d'actionnement (16), caractérisé en ce qu'un deuxième dispositif d'actionnement (10) est utilisé pour obtenir un mouvement composé du point de mire, mouvement qui est constitué d'une première et d'une deuxième composante de mouvement radiale produite respectivement par le premier et le deuxième dispositif d'actionnement, les premier et deuxième dispositifs d'actionnement étant commandés de telle manière que la première composante de mouvement est un mouvement prédéterminé dont la direction n'est pas renversée et que la deuxième composante de mouvement est un mouvement de va-et-vient prédéterminé, l'exposition de la surface d'enregistrement au faisceau de rayonnement étant interrompue au moins pendant le retour du mouvement de va-et vient, dans un cycle correspondant à n mouvements de va-et vient consécutifs pendant les allers consécutifs desdits mouvements, la surface d' nregistrement étant balayée chaque fois suivant un nombre entier g (y compris 1) de spires d'un sous-spirale, raison pour laquelle les vitesses de la première et d la d uxième composante de mouvement pendant les allers sont choisies de telle manière qu la vitesse du mouvement composé est sensiblement proportionnelle à la vitesse angulaire du support et les vitesses des composantes de mouvement pendant les retours sont choisies de tell manière que le point d mire est transféré vers l point où le balayage suivant la sous-spirale suivante a été interrompu.

2. Procédé selon la revendication 1, caractérisé en ce que la durée d'une période de la deuxième composante du mouvement de va-et-vient correspond sensiblement à p révolutions, p étant un nombre entier supérieur ou égal à q, les vitesses de la première et de la deuxième composante de mouvement pendant les allers de la deuxième composante de mouvement étant choisies de telle manière que la vitesse du mouvement composé est sensiblement proportionnelle à la vitesse angulaire du support pendant un intervalle de temps ininterrompu correspondant au moins à g révolutions et le point de mire étant déplacé dans un sens radial sur une distance correspondant sensiblement à 1/n fois le pas de la n spirale pendant une période entière de la composante du mouvement de va-et-vient.

3. Procédé selon la revendication 1, caractérisé en ce que la première composante de mouvement est sensiblement égale à zéro pendant l'aller de la deuxième composante de mouvement.

4. Procédé selon la revendication 2, caractérisé en ce que la vitesse de la première composante de mouvement est sensiblement proportionnelle à la vitesse angulaire du support.

5. Procédé selon la revendication 2 ou 3, caractérisé en ce que p est égal à q.

6. Procédé selon la revendication 1, 2 ou 3, caractérisé en ce que n est égal à 2.

7. Dispositif d'enregistrement optique pour mettre en oeuvre le procédé selon l'une des revendications 1 à 6, comportant un moyen d'entraînement (3) pour imprimer un mouvement de rotation à un support en forme de disque (5) présentant une surface d'enregistrement sensible au rayonnement, un système optique pour diriger un faisceau de rayonnement vers un point de mire sur la surface d'enregistrement, et un premier dispositif d'actionnement (16) pour déplacer le point de mire radialement sur la surface d'enregistrement dans un premier domaine de déplacement, et des moyens pour commander le premier dispositif d'actionnement afin de créer une première composante de mouvement du point de mire, mouvement qui n'est pas renversé, caractérisé en ce que le dispositif d'enregistrement optique comporte un deuxième dispositif d'actionnement (10) pour déplacer le point de mire radialement sur la surface d'enregistrement, dans un deuxième domaine de déplacement inférieur au premier domaine de déplacement, de manière à créer un position composée du point de mire, des moyens pour commander le deuxième actionn ur afin d créer un composante de mouvement d va-et-vient tell que, dans un cycl correspondant à n mouvements de va-et-vient consé-

cutifs pendant les allers consécutifs du mouvement de va-et-vient, la surface d'enregistrement est balayée chaque fois suivant un nombre entier g (y compris 1) d spires d'un sous-spiral et qu , pendant les allers du mouvement de va-et-vient, la vitesse du mouvement composé est sensiblement proportionnelle à la vitesse angulaire du support et pendant les retours du mouvement de va-et vient, le point de mire est transféré vers le point où le balayage suivant la sous-spirale suivante a été interrompu.

8. Dispositif d'enregistrement optique selon la revendication 7, caractérisé en ce que le deuxième dispositif d'actionnement est un dispositif de déviation acousto-optique pour dévier le faisceau de rayonnement dirigé vers la surface d'enregistrement.

9. Dispositif d'enregistrement optique selon la revendication 7, caractérisé en ce que le deuxième dispositif d'actionnement est un dispositif de déviation électro-optique.

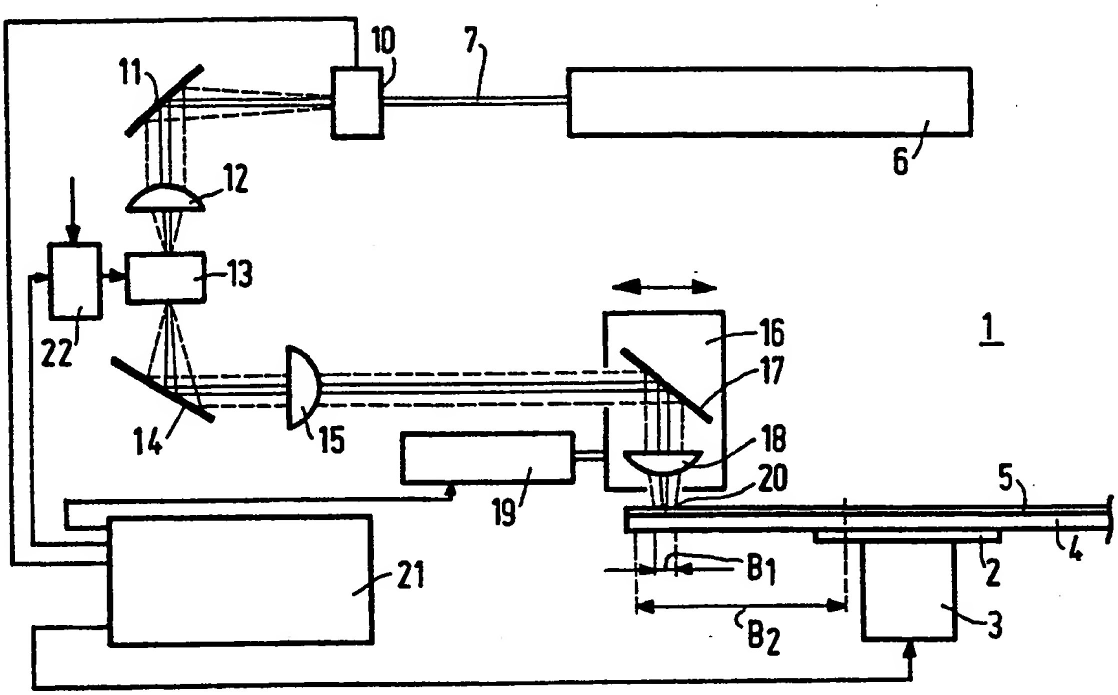

FIG.1

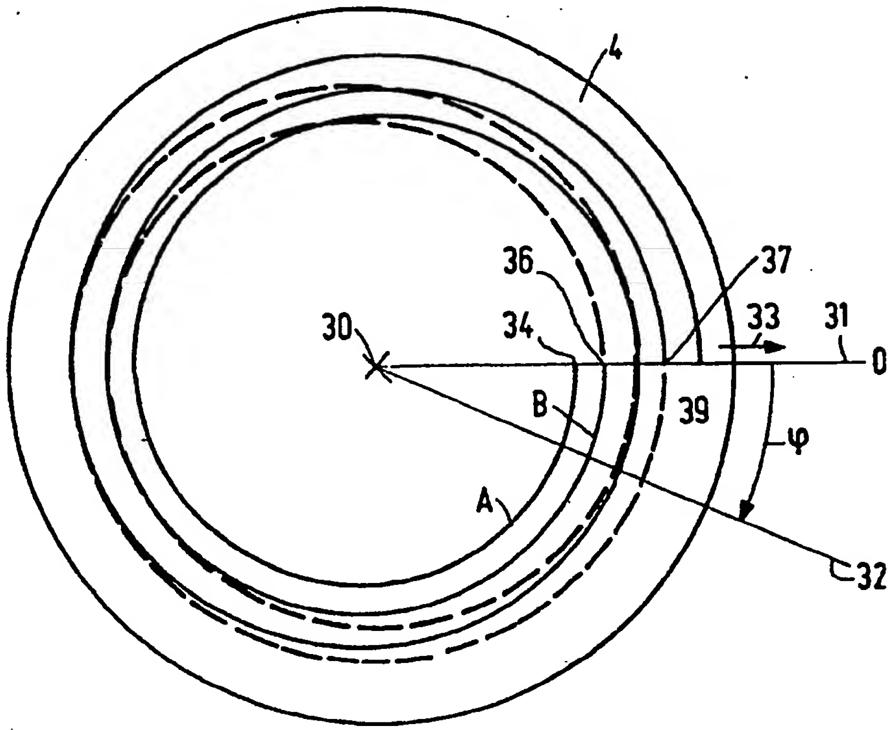
4
36
37
30
34
33
31
0
B
39
φ
A
32

FIG.2

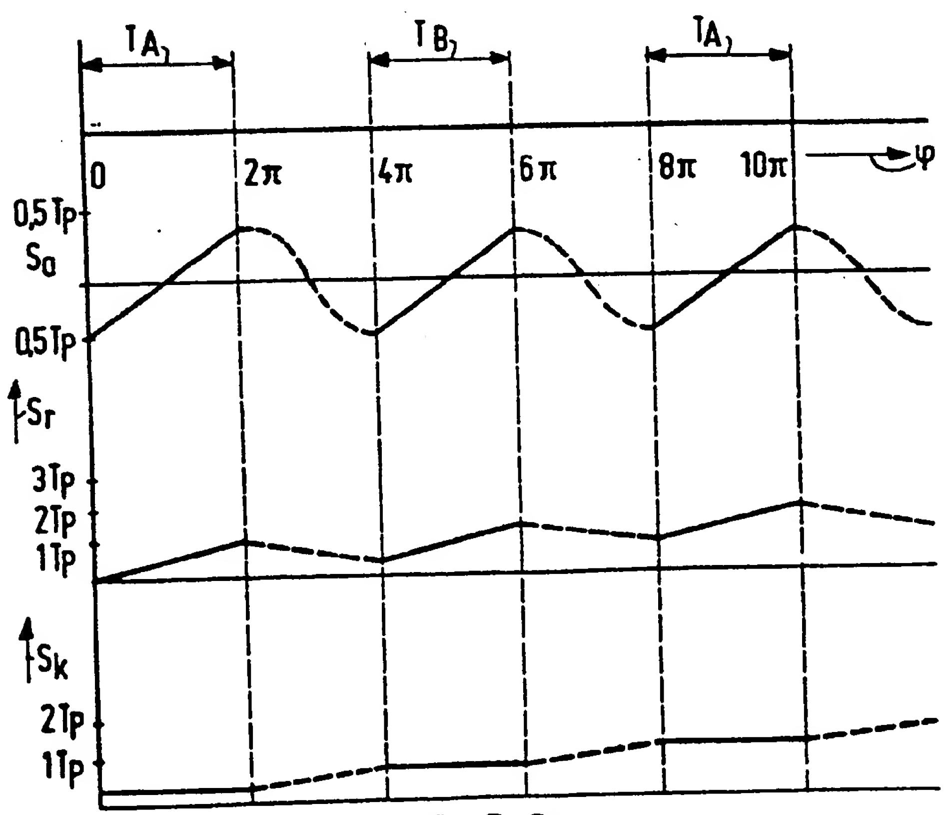
TA
TB
TA
0
2π
4π
6π
8π
10π
φ
0,5Tp
Sa
0,5Tp
Sr
3Tp
2Tp
1Tp
Sk
2Tp
1Tp

FIG.2a

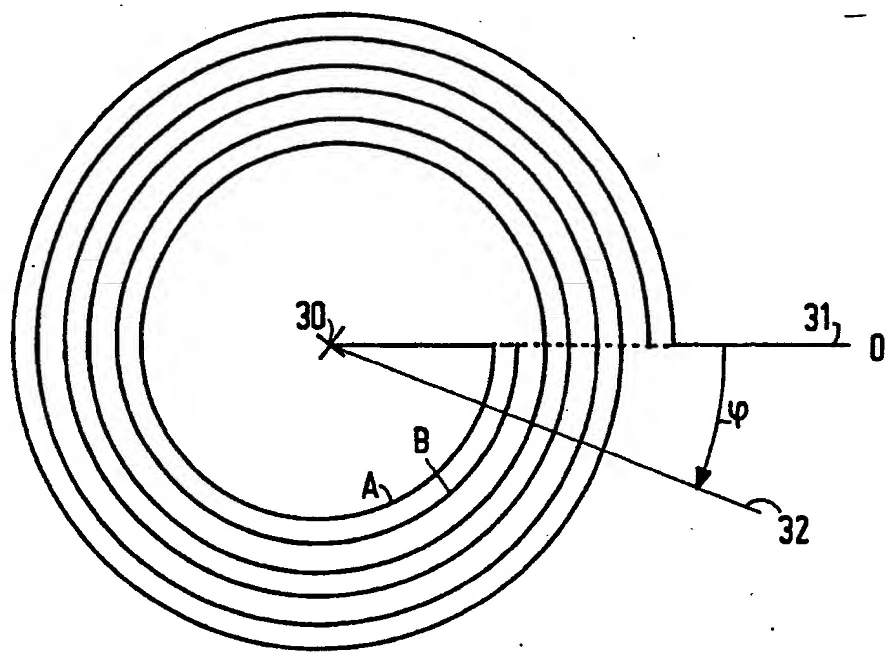
30
31
0
φ
B
A
32

FIG.3

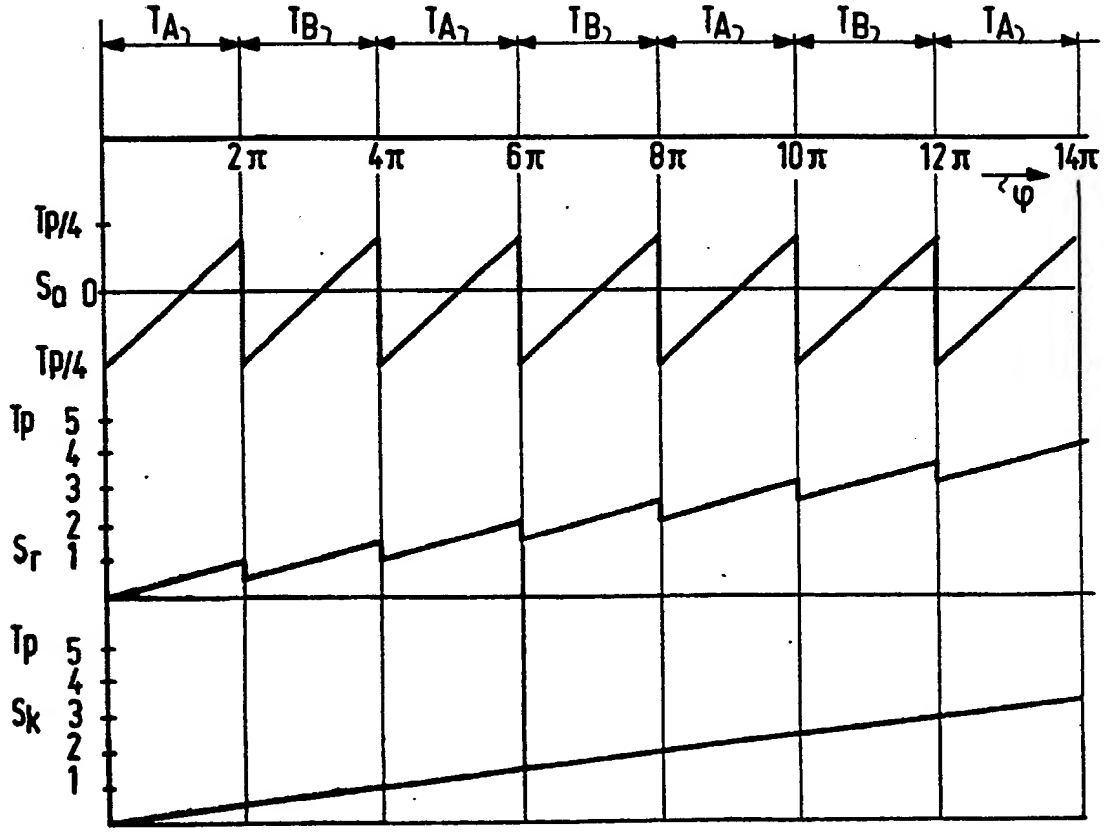
TA
TB
TA
TB
TA
TB
TA
2π
4π
6π
8π
10π
12π
14π
φ
Tp/4
Sa 0
Tp/4
Tp 5
4
3
2
Sr 1
Tp 5
4
Sk 3
2
1

FIG.3a

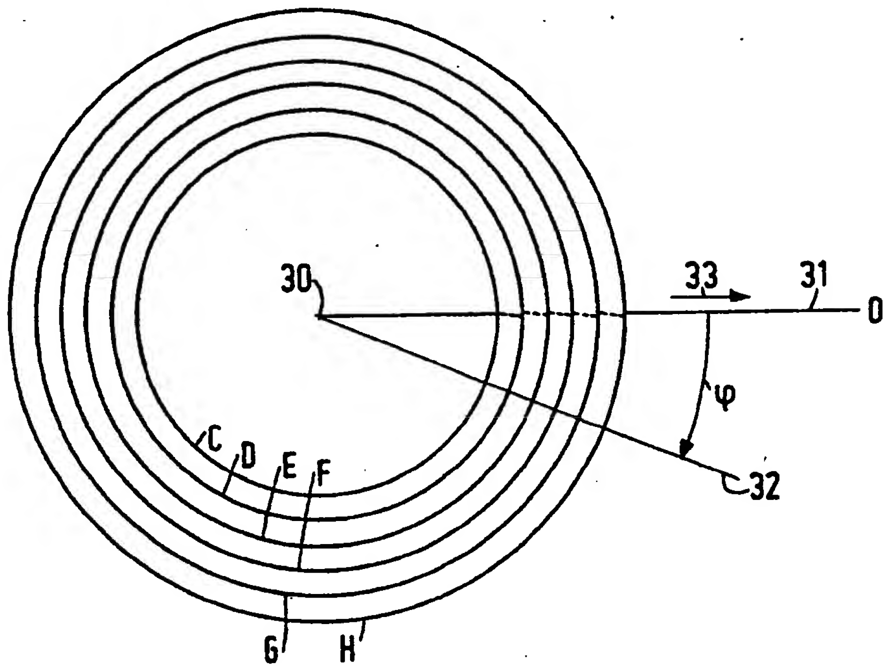
30
33
31
0
φ
32
C
D
E
F
G
H

FIG.4

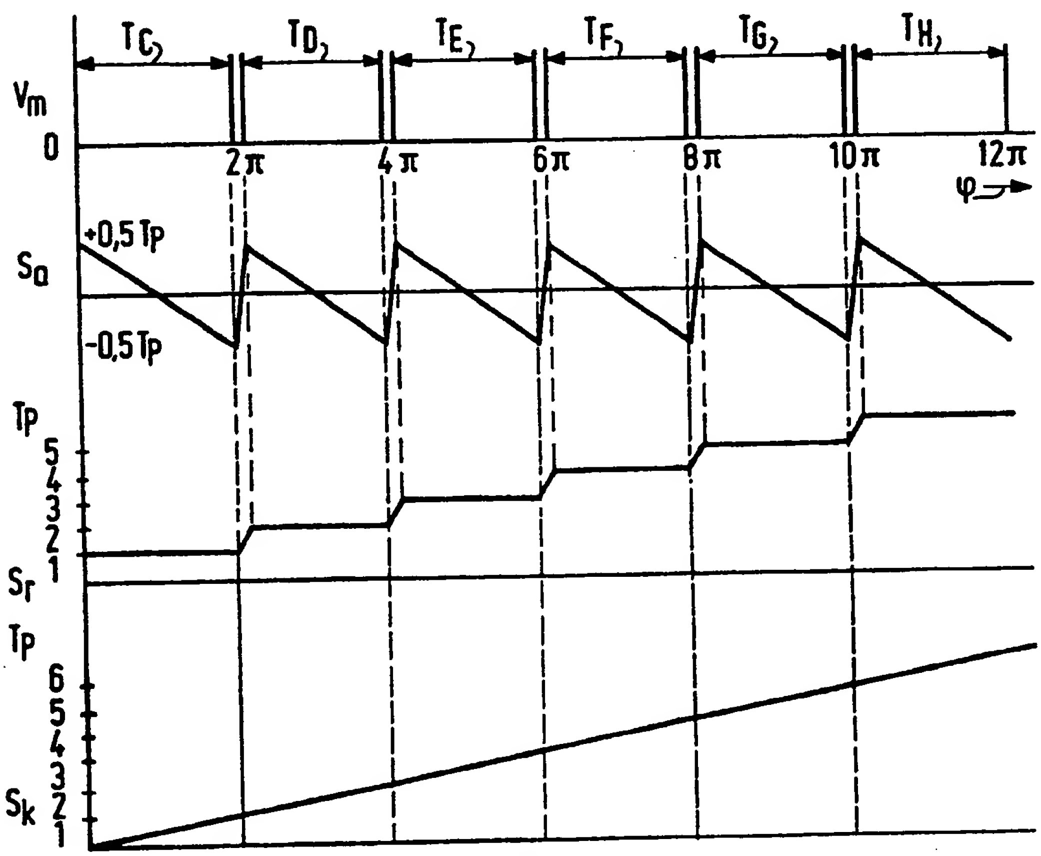
TC
TD
TE
TF
TG
TH
Vm
0
2π
4π
6π
8π
10π
12π
φ
+0,5 Tp
Sa
-0,5 Tp
Tp
5
4
3
2
1
Sr
Tp
6
5
4
3
2
1
Sk

FIG.4a

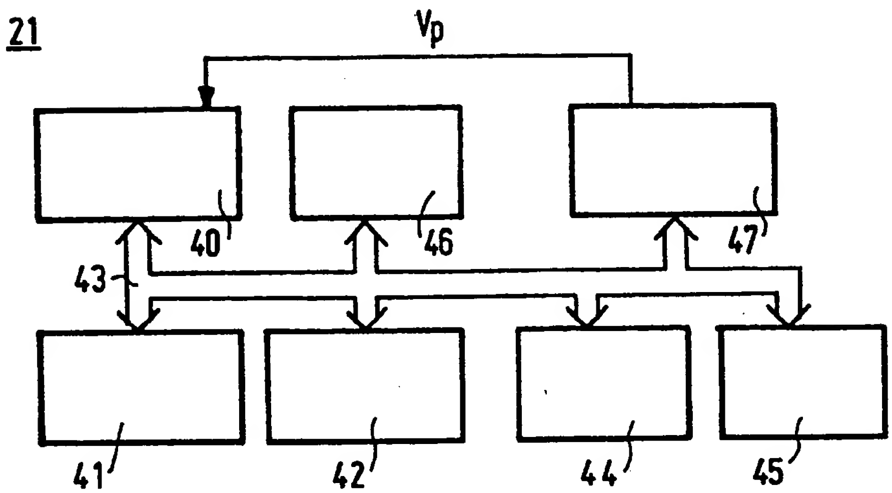

FIG.5

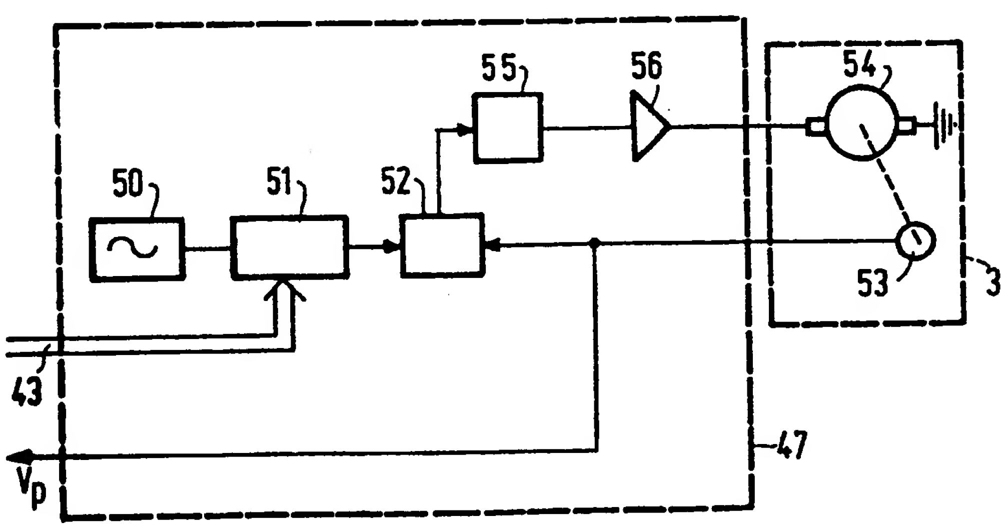

FIG.6

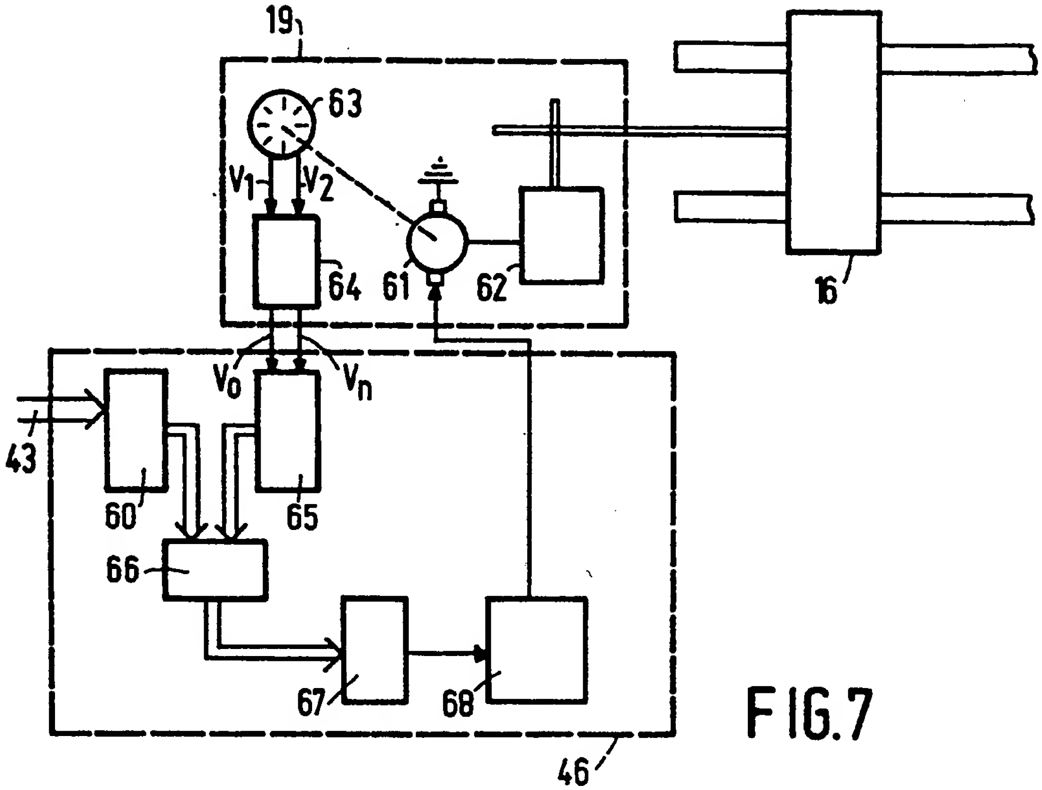

FIG.7

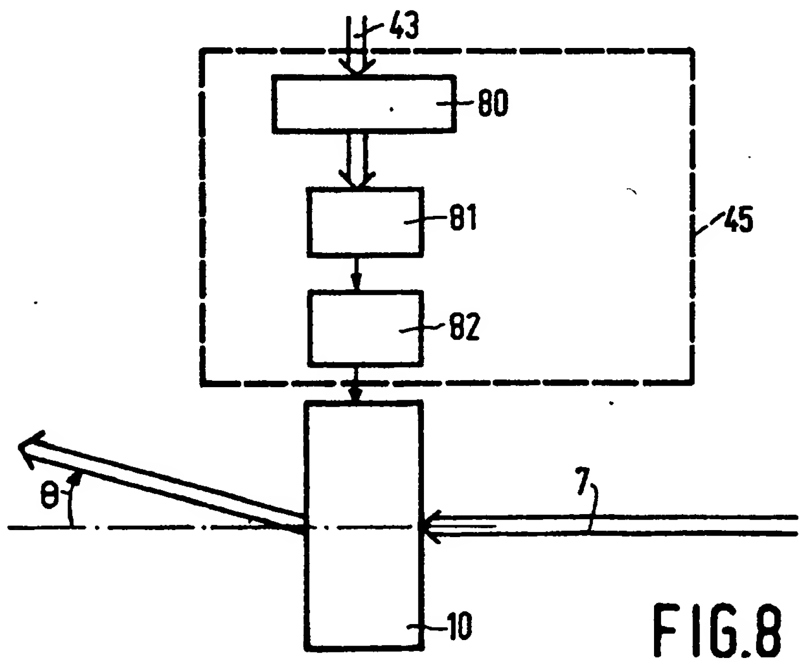

FIG.8

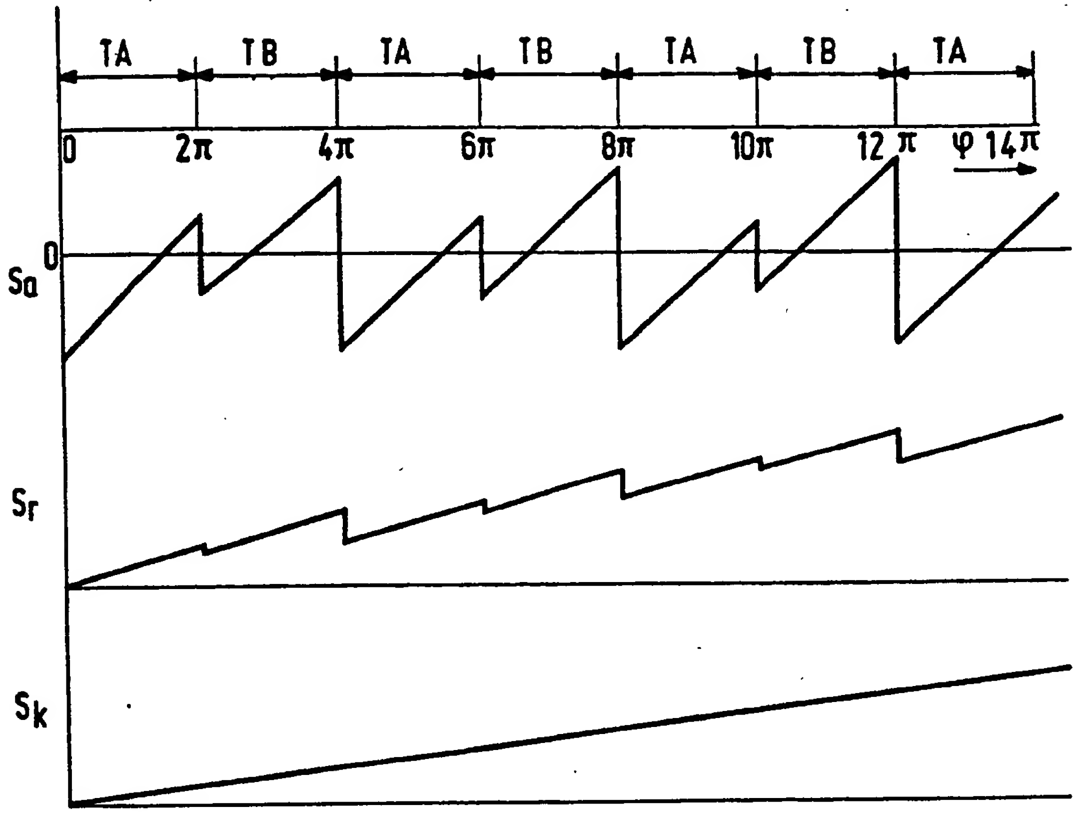

FIG.9a

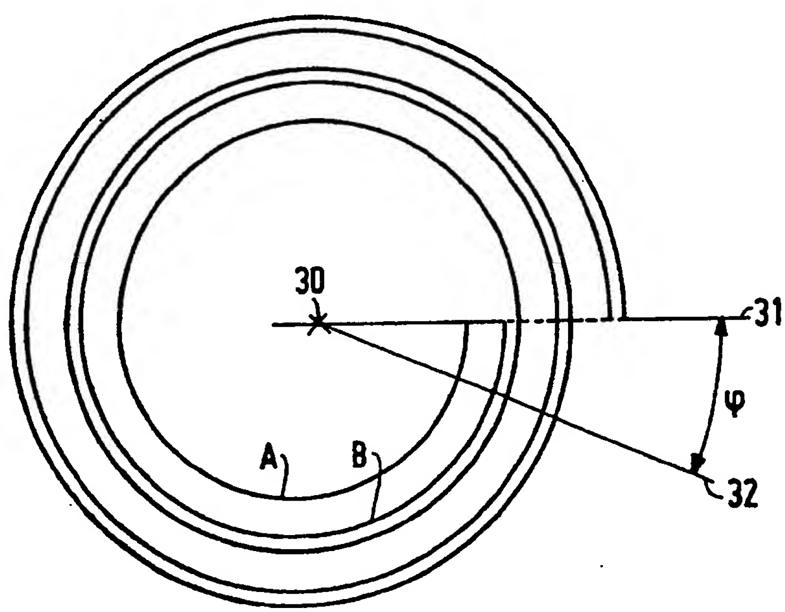

FIG.9b